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Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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The Future of Plastics in Aircraft

THE past few years has seen the growing use of plastics applied in aircraft, and coincident with this growth there has been some general description of such uses in the trade literature and, indeed, some measure of scientific debate regarding present and future possibilities. While real information on small points is available, speculation has been rife as to what (if anything) is going on behind the scenes in the large aircraft factories. In fact, we have all wanted to hear the aircraft manufacturer's opinion as to the real value of plastics as materials of construction for aircraft.

It is, of course, supremely important for us to know the truth of the matter—what aircraft manufacturers require of new materials, so that they might, if approved, replace or co-ordinate with existing ones. But obviously, since the modern plastics industry is so young, indeed we are still delving into the mysteries of resin formation, we cannot expect too much. On the other hand, the industry has acquired a considerable moulding technique in one form or another. Altogether there should be, and, indeed, there is, a common meeting ground for both industries.

However, the main point is that we want to know what the aircraft manufacturer wants, and he wishes to know how far we can supply it. It was, therefore, an eager and a very considerable gathering of the Institute of the Plastics Industry that met on January 25 at Oddenino's to hear Mr. J. D. North, of the famous concern of Boulton and Paul.

Mr. North is an acknowledged world authority on aircraft construction and design, and, as we have said, we did not expect lavish praise of materials that are comparatively new from the engineering standpoint, but we did not expect the blast of his talk to blow so coldly. Let us be candid: it struck a chill into every plastic technologist's heart.

It is difficult to say what we did expect from Mr. North. Most of us (without any real reason, we might point out) expected a general talk on the value of plastics in aircraft. What we got was one which might have been entitled, "Can the bodies and wings of big bombers and fighters be made of plastics?" Moreover, it was a cold mathematical analysis of plastics, the compiled results, as it were, of a pure scientist who had been given a sample of a metal and a sample of a plastic, and had been told to produce a series of comparative tables of mechanical and physical tests. This is exaggerating the matter considerably, for we know Mr. North's vast manufacturing experience.

He told us of the stupendous stresses which the big machines undergo (the tendency is for larger and even faster aeroplanes), and of the very severe conditions of sudden and extreme changes of temperature under which they fly; he also showed how much lower is the crushing strength of all plastics compared with metals, that tensile strength and specific tensile strength was not so important in aircraft materials, that the high coefficient of expansion of plastics was a bad thing, that low ductility or brittleness limited their use, and that repairs could not be readily carried out with plastics when enemy action had inflicted damage. In effect he could not conceive any form of known plastics that could replace metal.

How thoroughly we agree with him, and who on earth in the plastics industry ever thought plastics could replace metals for these large structures? The plastics industry is composed on the one side of a number of chemists and physicists, who know a great deal of what they are making and who know that they can gradually improve upon it, and on the other side of a number of expert engineers, who fabricate from plastics. Neither set believes that the modern enormous aircraft can be turned out in a sort of sausage machine. In fact, their attitude towards the aircraft industry has been correct and reasonably careful, beginning with the so-called gadgets, the internal fixtures, the panels and radio and electrical equipment, the conduits, the wheels, the airscrews, and the hundred and one other moulded or laminated objects that exist in every aircraft. It has all been done step by step, after due analysis. They have never thought in terms of Hampden or Stirling wings or fuselages. On the other hand, they have thought in terms of very small craft, and cannot quite believe that the Timm trainer or the Vidal experiments are completely ridiculous notions. We cannot quite believe this, because important American concerns have taken a lively interest in them, because such craft have been built and flown, and the peculiar method of manufacture is one that displays a knowledge that plastics need not, and perhaps should not, be dealt with by the methods of metal fabrication.

We should like to stress that, in our opinion, the great bombers and fighters are not our meat at all—as yet. But we do believe that when peace comes there will be a great demand for the small, low-priced craft for pleasure cruising, something that can travel at, say, 75 to 80 m.p.h. at 5,000 ft., with a 25 h.p. engine and weighing not more than a few hundred pounds. Surely plastics has a future in such a construction. We admit that, compared with metals, plastics are brittle, and if hit with a stream of bullets from a Messerschmitt will show an ugly deterioration difficult of repair; but we do not believe people will go shooting-up users of the air in peace-time.

We are reminded of the British motor-car manufacturers who jeered at the idea of the moulded plastic car, and how Mr. Ford, using entirely new technique in construction, quietly went ahead and made a prototype, and appears to be very proud of his achievement.

A few had gone to the lunch hoping to be patted on the back for the work of the plastics industry in war-time. Most of us do not care too much for that sort of thing, and like to get down to brass tacks, but all of us did hope for a bit of encouragement and for imagination.

The World of Substitutes

A short time ago we were asked to give a lecture on the subject of plastics and were told to stress the fact that plastics are not substitutes. We did nothing of the kind, for plastics are indeed substitutes. Every material has been a substitute at some time in its history.

By some curious twist of the mind of the man in the street, and even of others who should know better, the word " substitute " has assumed a meaning indicating inferiority. It does not mean anything of the kind. It is not pedantic to indicate that the word simply means a material which replaces another, so that surely we have, very roughly, three types

of substitute, a bad, a good (or perhaps equal) and a better.

No doubt when some of the Early British maidens doffed their woad and accepted the first Phœnician wool jumpers they did not sneer at this new substitute. Nor did their fathers when they were attacked with steel swords when they only had stone clubs. They were only too glad to steal a few examples of the substitute when opportunity arose. When glass replaced horn people did not regard it as inferior because it was a substitute. We remember long ago using gold crucibles in a laboratory and substituting them with platinum when we could afford to do so.

We have always thought that the era of bad substitutes began roughly in the 1870s. There have been inferior substitutes, of course, ever since trade began, but we have always regarded the introduction of margarine as the beginning. This was during the Franco-Prussian war and the substitute for butter, no doubt with good reason, has been looked upon as inferior.

Later during the intense manufacturing periods of 1880 onwards, especially in Germany, a number of new processes and materials of the "composition" type gave further weight to the change of meaning. Thus those plaster models which simulated bronze or marble were much inferior and flooded the world with a new crude art. It was also a time when painters began their horrid decoration to simulate woods. Composition balls were certainly somewhat inferior to "ivory" billiard balls since they did not possess the elasticity of the natural material.

What of modern plastics? The situation is rather complex, but the story of our industry tells of all types of substitutes, the bad, the good and the better. We take it that the copying of, say, a marble vase in texture and colour is a bad substitute because of the pretence to be something which it is not and cannot be. When a plastic structure fails because it is too weak for the job, again it is a bad substitute. And of course when it replaces a brittle object or has improved chemical or physical properties it is a better substitute. Or again when a unit can be moulded in plastics in one shot, when the same shape takes two or more separate parts in another material to make, the general consensus of opinion is that it is better than the material it substitutes. The synthetic fibres may be put in an ascending order of merit compared with natural silk: viscose (not very good), acetate (better than viscose but still much below silk) and nylon (reputed to be as good as, if not better than, silk). Finally there are the synthetic rubbers, some of which have such excellent resistance to oils and to ageing as to be far superior to natural rubber.

Regarding them all, by and large, it would seem that plastics are improving in properties so rapidly that the word "substitute" will one day assume, even in the mind of the man in the street, a meaning of superiority!

Synthetic Rubber

THE capture of Malaya by the Japanese gives some of us the very poor satisfaction of saying: "I told you so." We have now been deprived of some 70 per cent. of the world's rubber.

After the last war the Government had wisely considered the dyestuffs industry, which, before 1914, had been almost entirely in the hands of the Germans, to be a "war industry" vital to the welfare of the nation in time of war, and, as a result, included it in the Key Industries, so that dyes were manufactured under Government protection; that is, almost all foreign dyes were prohibited entry. It might be noted that since those days over 95 per cent. of the dyes we require have been made here.

About the same period a number of people, amongst whom we included ourselves, urged that calcium carbide should also be considered as a Key Industry, and conducted a small and very unsuccessful campaign to enthuse others. It was based by no means on synthetic rubber only, although this was included on general grounds. Indeed, none of us thought

that high-quality synthetic rubber would be available for very many years. But 100 per cent. of our carbide was imported in 1914 from Scandinavia and Canada. It still was until 1939.

We urged its manufacture here because of the vast quantities required in war-time for welding and metal cutting, and because from it chemists can make acetic acid and alcohol and thence a host of other chemicals, all of which we have otherwise to make by the fermentation of molasses brought in ships from the other side of the Atlantic. To-day an important section of the plastics industry, which includes synthetic rubbers and polyvinyl compounds, depends partly on acetylene, that is, carbide production. Since carbide is made from coal and lime with the aid of cheap electricity, the suggestion can be considered a reasonable one for this country. Even if the manufacture of synthetic rubber were deemed too costly a procedure, we have now ample proof that, if only from the welding and metal-cutting point of view, carbide manufacture fully justifies itself. There was never any suggestion of making ourselves self-sufficient in synthetic rubber, since we have always believed in the development of natural materials, but if we had had a large carbide industry and the nucleus of a synthetic-rubber industry in 1939 the expansion could have been made.

Mr. Averill Harriman, of the U.S.A., has just declared that America has enough stocks of natural rubber to last 18 months, and by then will be making enough synthetic rubber for all the Allies.

Mr. Macmillan, of the British Government, has just told us that there is no need for this country to make synthetic rubber, since America has the petroleum and can make it for us. We have never yet encountered a more supine attitude. He has probably never heard that as much synthetic rubber is made from coal or alcohol as from petroleum. He deprives this country of the opportunity for some of the most important research work that has ever been offered us. His speech indicates he is not a giant of intelligence. It fills us, indeed, with foreboding. We can only stand by and shake with rage.

SEEING HOW IT WORKS.—As readers will have guessed, we have always been keen on the progress made in fabricating transparent engineering units either for real service use or as models for research. In our October, 1941, issue we published some beautiful photographs of such work carried out with Catalin. We have just received information that Runcolite, Ltd., has begun production on these lines and has already made amongst others one extremely interesting model which we examined on visiting the offices. It is a connecting-rod showing the flow of oil for lubricating the system. We shall be receiving a photograph of this in due course and hope to publish it in our next issue. During our visit we suggested that an interesting model could be made, either for research or display purposes, of a centrifugal pump. We were promised that a working model would be made. We hope to give more information on this too.

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THE PLASTIC WALL

An Approach to Problems of Weather-resistance

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SOME understanding of the conditions under which walling fails to withstand the elements is essential to the plastics manufacturer who proposes to adapt one or more of his materials for this purpose. The recorded knowledge on this subject is extremely confusing and until scientific methods of test were worked out by the Building Research Station the utmost confusion existed. Every local builder or architect had his own pet theory based upon casual observation or the tradition of the district. Now, however, certain principles are emerging, and although they apply to conventional materials such as brick, stone, concrete, etc., they provide the only basis for criticism.

The Durability of Wall Structures

The durability of walling should depend largely on intention. Traditionally, walls were built to last for centuries, but under modern conditions there is a growing opinion that one's house, like the motorcar, should be designed to last for a limited period—say, twenty-odd years, by which time new habits of living, new conceptions of plan and material and a new æsthetic outlook combine to make the structure obsolete. This would be especially the case with the factory-made plastic house where the likelihood is that new plastics and a widening range of compounds, following rapidly upon each other, would tend to date various models by their year of production. Accepting this view, one could choose a plastic material with a time limit of durability within which period no maintenance expense would be necessary.

Failure by penetration of water is deemed to have taken place when the internal walls are either damp to touch or if discoloration has taken place or if internal wood linings show signs of rotting. The penetration of water is, however, permissible up to this stage provided the moisture can readily dry out. For this reason we have the apparently anomalous circumstance that a highly porous wall is not necessarily an inferior wall to that made from a dense material. Heavy rain blowing against a dense, impervious material runs down the face of the wall and streams through the tiniest joint or crack, whereas rapid absorption prevents running water.

Porosity, a Major Problem

Porosity, therefore, may be a decided advantage and consideration of the size of the pore structure and the capillary attraction exerted by small-pored materials is necessary to determine the ideal conditions.

On first consideration it might appear that these principles are irrelevant to the choice of material for plastic walling. One immediately assumes that plastic walls will be entirely sealed and waterproof, but it is of interest to record that a precedent exists for a plastic porous wall. At the last German Exhibition at Frankfurt a partially plastic house was built for exhibition purposes. The walls were constructed of stones or blocks of "light concrete" type of plastic composition. There can be little doubt that this idea will be followed up to advantage and efforts devoted towards research on suitable fillers, method of manufacture, etc., will be extremely valuable.

The alternative to the "porosity theory" is that of sealing the wall face entirely. In this case the protection must be 100 per cent. effective as the water will run down the walls in appreciable quantity searching for the slightest crack or joint, and if moisture penetrates in this way there is no reasonable chance for it

to dry out. The wall may become almost permanently waterlogged. The real problem of the "sealed wall," therefore, becomes the design of joints. Cover-stripped joints, besides being in many cases unsightly, may fail by the capillary attraction of water through an apparently well-designed joint. In the case of a mortar joint (in plastic walling the mortar may be a coloured synthetic mastic) there is the possibility, not remote, that the wall may shrink from the mortar, leaving perhaps only a hair-crack. This is, however, quite sufficient to facilitate the entry of an appreciable amount of rain water. The dimensional changes of the walling material and the synthetic mortar must be carefully studied and a body of knowledge accumulated on the basis of empirical tests.

Plastics for Wall Surfaces

The choice of a suitable plastic for the surface of the wall should not be difficult from the point of view of water absorption. While no specific plastic is recommended at this stage it is of interest to note available figures for various synthetics after the 24-hours' immersion test. Polystyrene commands attention with a water absorption figure of nil. The material, however, is slightly brittle and comparatively expensive meanwhile, but the low specific gravity of 1.05 commends itself for lightweight prefabrication schemes. It also has the advantage of being easy to work for high-speed production.

Vinyl chlorides and vinyl acetates are of interest with a figure of 0.1 for water absorption. The materials are tough and the co-polymers can be worked to a wide range of consistencies. They are highly resistant to chemical action and have an enviable colour range. No specifications are available and data on costs are difficult to come by. There can be no doubt, however, that the use of these co-polymers for building purposes is a certainty and the range of applications will be wide.

Failure due to the action of weather may take place by the absorption of water, which, under conditions of frost, expands and bursts the walling material. This is commonly observed in the form of crazing or cracking of cement or like renderings on the surface. The water absorption of building bricks may vary between 20 per cent. and 30 per cent. of their weight and the effect of frost can well be imagined. The majority of known renderings are brittle and failure by freezing and flaking is widespread through the building industry.

Chemical Corrosion in Structures

Another common cause of failure is that of chemical erosion. Atmospheric acids are deposited in the pore structure by the medium of rainwater. The crystallization of salts within the pores leads to the formation of a hard skin on the surface and through time the process of flaking takes place. The chemical composition of the walling material itself must be carefully studied to prevent unforeseen chemical action taking place and so causing efflorescence or other forms of discoloration. British Standard Specifications are available for most normal materials, but new plastic materials require careful examination and reliable tests by recognized authorities. The indications are, however, that many plastic materials are chemically inert, and it can be confidently anticipated that the problem of chemical erosion will cease to be of any account when synthetics come to be adopted by the building industry.

It is apparent that the laboratory development of plastic walling, whether in sheets, panels, blocks, etc., falls into two general classifications—the porous wall structure or the sealed wall face. It would be difficult to forecast at this stage which method of approach would be conducive to the best results. A reasonable basis for criticism already exists largely through analogy with brick, stone, concrete, foamed slag and like porous materials. From a purely theoretical point of view the idea of absorptive materials is not appealing. Success along this line appears to depend too much upon a delicate

balance between too great porosity or too little porosity, and while a good working average may be achieved in the laboratory the conditions of exposure on the actual building site may vary between extremes. Indeed, as things stand at present, building materials are often chosen in accordance with known weather data which varies greatly between one district and another. It can be seen, therefore, that an arbitrary formula for the composition and internal structure of a porous walling material may lead to anomalies in actual practice.

On the other hand, the sealed plastic surface can be readily achieved with a variety of synthetic materials, but the essential safeguards against weather penetration are merely transferred from the material to the joints and fixing. The problem is transferred from the manufacturer's laboratory to the architect's studio and the problem of the design and fitting together of the various components assumes vital importance.

Under normal conditions as at present obtaining in the building trades the ideal of 100 per cent. efficiency is seldom realized, but nothing less will meet the case. Perhaps this is the reason for avoidance, until now, of sealed wall techniques. The advent of complete prefabrication under controlled factory conditions promises to reverse the position. Industrialized methods will lead to highly perfected standardized methods and type designs for housing. The preliminary thought and research which is necessary before a new model goes on to the assembly line provides the opportunity to solve these problems of detail once and for all. Tolerances of building parts can be scientifically charted as against the present-day dependence on the skill of individual craftsmen.

Again, the introduction of prefabricated methods tends to arise from the enterprise of manufacturing concerns anxious to exploit the advantages of a limited number of proprietary materials. While theoretically this tendency is unscientific and therefore to be avoided if possible, it can be demonstrated that certain advantages may result. The entire house can be treated as one problem by individuals who are experts in the manipulation and application of their own materials. The labour is not divided as at present and the resultant co-ordination leads to a high level of all-round efficiency.

It can be said, therefore, that the introduction of plastic materials for walling will lead to new standards of excellence in respect of weather resistance and will constitute another important step towards the achievement of prefabrication in the post-war period.

Resins as Microscopical Mountants

In 1940 the problem of a suitable plasticizer for polystyrene was put to us by Mr. Lendrum, a well-known worker in this field. Since readers may be interested in this topic we have pleasure in reproducing the following, written by Messrs. Lendrum and Kirkpatrick, in a recent issue of the "Journal of Pathology and Bacteriology" (Vol. LIII, No. 3, pp. 443, 1941).

SOME months after our publication on the use of a synthetic resin—the polystyrene, Distrene 80*—as a mountant for microscopical preparations (Kirkpatrick and Lendrum, 1939), we observed the appearance in some of the histological preparations of tiny refractile bodies. These occurred both as thin needle-like crystals and as small irregularly curved flat plaques; they were quite colourless and the finer ones became visible only on reducing the aperture of the diaphragm. They had not been noticed in mounts of smears or films.

It has now been found that these bodies are the results of mounting sections from a jar of xylol previously used for dewaxing. Slides were immersed in a strong solution of wax in xylol, and from this

* Obtainable from British Resin Products, Ltd., Great Burgh, Epsom, Surrey.

were mounted in balsam and in polystyrene; control slides were mounted from pure xylol. Within a fortnight the polystyrene mounts from waxy xylol showed abundant bodies, whereas the balsam mounts showed not a trace of precipitation after two months. Films mounted in balsam from a saturated solution of wax in xylol failed to show precipitation after a year. This toleration on the part of balsam may be explained in part by a persistence of the solvent xylol in the mount; it certainly is a fact that balsam mounts even after years are still tacky in the centre. Other writers (Groat, 1939, 1940; Davies, 1939-40; Lillie, 1941), working with Clarite (a cycloparaffin polymer) and with methacrylate polymers, make no mention of this trouble. It is possible that these substances have the high tolerance for wax shown by balsam, or it may be that, in the routine processing, other laboratories do not use the same dish of xylol for de-waxing and for final clearing, a form of economy that we practised only with the diagnostic biopsy material and one that is justifiable if balsam be used. The use of fresh xylol before mounting prevents the formation of the bodies in polystyrene mounts.

Type of Plasticizer

When these deposits were first noticed we made inquiries as to the possibility of plasticizing with substances other than tricresylphosphate. Our suspicion that the tricresylphosphate was the cause of the deposits was only later transferred, as it proved with justice, to the paraffin wax. The use of dibutylphthalate was suggested to us by Dr. Tucker (of the Department of Organic Chemistry) and by Mr. M. D. Curwen (editor of "Plastics"); apparently this substance is, on theoretical grounds, more suitable than tricresylphosphate for combination with a polystyrene (Curwen, 1940). A mountant called, for brevity, B.P.S., was prepared as follows:

Five c.c. of dibutylphthalate (B.D.H.) are mixed with 35 c.c. of xylol; in this are dissolved 10 g. of Distrene 80. Preparations made with this solution have shown no degradation after 14 months, while the preservation of colour and the refractive index and the lack of retraction are fully as good as in those prepared with the earlier solution. This medium is just as intolerant of paraffin wax as that made up with tricresylphosphate. The new solution has the distinct practical advantage of forming a less tacky surface at the edge of the coverslip and of hardening there as quickly as balsam.

It may be added that the lapse of time since our earlier publication has given further proof that the synthetic resin preserves the colours of bacteriological preparations very much better than balsam. In histological preparations, the more fugitive stains have been well preserved; for example, malachite green and acridine red, eosin and methylene blue and other Romanowsky mixtures. Some of the hæmalum and eosin sections, however, have shown fading, a fact that cannot as yet be adequately explained. These were in an uncontrolled series; where parallel balsam and polystyrene series have been prepared, the hæmalum and eosin staining has proved particularly and equally persistent.

The reader interested in polystyrene should consult the paper of Staudinger and Stanley (1938); the subject of plasticizers is dealt with by Clark (1941).

Summary

The use of a synthetic polystyrene resin (Distrene 80) in place of Canada balsam demands the complete removal of paraffin wax from the slide.

The use of dibutylphthalate as the plasticizer has certain advantages and seems in no way to diminish the superiority of this medium over Canada balsam; it does not remove the need of dissolving away all paraffin wax.

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PLASTIC SHEET and FILM MATERIALS

The author continues his discussion of the types of plastic sheet used as wrapping with special reference to "moisture proofness"

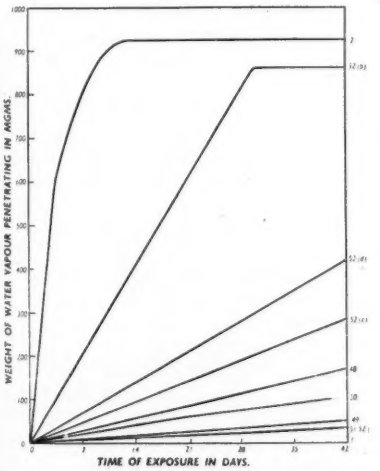


Fig. 7.—Moisture permeabilities of rubber and Pliofilm.

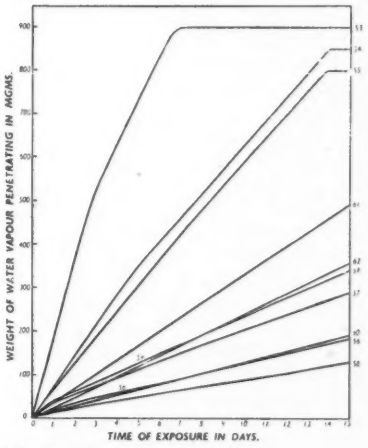


Fig. 8.—Moisture permeabilities of organic finishes.

By
E. E. HALLS

TABLE 4 deals firstly with rubber, interesting because it is used extensively for bottle closures, for linings, as well as for specific sealing against ingress of moisture, and as well as for the basis of the stickant on many adhesive paper and fabric sealing tapes. The first point of note is that rubber is not completely immune from penetration. The second one is that rubber strained by stretching is superior to the original material.

Table 4 also shows the relatively new American packaging foil Pliofilm, the stable rubber hydrochloride compound. Sample No. 51 shows this to be amazingly good, while No. 52 (a) amply illustrates its "staying power." The artificial ageing tests strike a note of warning in connection with continuous dry heat exposure, but also show some appreciable deterioration under the remaining conditions. The severity of these conditions, of course, must not be overlooked, and undoubtedly Pliofilm is a moisture-proofing material of outstanding merit.

The values from Table 4 are graphed clearly in Fig. 7.

Table 5 does not deal with plastic films but with applied finishes of paint, varnish or lacquer, tested by applying two coats to one side of a film of cellulose acetate (0.0010 in. thick, similar material to No. 38, Table 3), allowing to dry out completely over a period of at least a week

Table 4.—Moisture Permeability Values of Rubber and Pliofilm Sheet Materials. Values Expressed in Mgms. of Water Penetrating.

Sample No.	Material	Thickness, ins.	Period in days of Exposure to 100% humidity gradient									
			1	2	3	5	7	14	21	28	35	42
1	Blank with metal membrane ..	0.010	Nil	—	—	—	—	—	—	—	—	Nil
2	Blank with no membrane	—	185	375	530	670	790	960	900	—	—	—
48	Rubber sheet	0.010	4	6	9	14	20	50	75	103	135	168
49	Rubber sheet (material No. 48) after holding under strain fully extended	0.008	1.5	2.5	4	6.5	8	18	25	34	39	45
50	Rubber sheet	0.005	3	5	7	14	21	44	60	75	91	105
51	Pliofilm	0.0010	1	2	3	5	7	13	19	25	30	35
52	Pliofilm, material No. 51 after ageing:—	0.0010										
	(a) Normal storage for 2 years		1.5	2.5	3.5	5	7	12	18	23	28	34
	(b) Exposure to dry heat at 60°C. for 42 days		25	59	80	142	205	403	610	810	860	860
	(c) Immersion in distilled water for 42 days		6	13	21	34	48	95	142	188	237	285
	(d) Subjection to cyclic humidity test for 42 days..		9	20	29	50	71	140	215	283	355	420

prior to assembling to the test cup. The same cellulose acetate without applied finish was used for conducting a blank test, so that the improvement (if any) attributable to the finish itself could be evaluated. It has already been pointed out that such finishing materials can be used to render papers and fabrics moisture-proof, and that applied finishes are used as the moisture-proofed regenerated cellulose films. Also, that cellulose dopes are used for bottle seals. The importance of this test series thus becomes apparent. The data shows the useful properties of tung oil varnish (No. 56), bituminous paint (No. 58), and shellac varnish (No. 60). They also place the synthetics, glyptal (No. 57) and polystyrene (No. 59), products in good order. The cellulose lacquer brushed (No. 55) is poor, but sprayed (No. 61) is reasonably good; but the combination lacquer (No. 62), a low consistency cellulose product containing synthetic glyptal resin ingredient, is superior, although it gives a thinner film. Table 6 shows the approximate thickness of the applied films. Fig. 8 graphs the results from Table 5.

As the use and utility of the applied finishes are regarded as of importance, the laboratory characteristics recorded on the materials employed are given in tabulated form. These values show the types employed, their total solid film forming contents and their consistencies. The majority of them are shown in Table 7,

Table 5.—Moisture Permeability Values of Applied Organic Finishes. Tested by Applying 2 Coats to 0.0010" Cellulose-acetate Film and Drying Before Fixing to Test Apparatus. Values in Mgms. Water Vapour Penetrating.

Sample No.	Finishing Medium	Brush or Spray	Period in Days of Exposure to 100% Humidity Gradient					
			1	2	3	4	7	14
53	Blank with no membrane ..	—	190	374	522	638	900	900
54	Blank with cellulose-acetate membrane, no applied finish ..	—	80	166	216	288	458	850
55	Clear cellulose brushing lacquer	Brush	85	140	186	234	423	800
56	Tung oil varnish	Brush	20	35	46	58	90	175
57	Glyptal synthetic varnish ..	Brush	34	56	74	93	175	320
58	Bituminous paint	Brush	12	22	30	39	66	120
59	Polystyrene lacquer	Brush	38	61	73	103	167	335
60	Shellac spirit varnish	Brush	17	29	39	52	91	185
61	Cellulose spraying lacquer ..	Spray	35	65	100	131	238	462
62	Cellulose synthetic combination lacquer	Spray	23	42	61	80	155	293

Table 6.—Average Thickness Values of the Applied Finish Films in the Tests of Table 5.

Sample No.	Applied Finish	Average Thickness, ins.
55	Clear cellulose brushing lacquer	0.0015
56	Tung oil varnish	0.0020
57	Glyptal synthetic varnish	0.0020
58	Bituminous paint	0.0020
59	Polystyrene lacquer	0.0010
60	Shellac spirit varnish	0.0020
61	Cellulose spraying lacquer	0.0010
62	Cellulose synthetic combination lacquer	0.00025

while Tables 8, 9 and 10 deal with the polystyrene, shellac and cellulose-synthetic materials respectively. The data are self-explanatory.

The moisture permeability data are in the main self-explanatory. One feature is, however, worthy of note. Not only is permeation dependent upon the nature of the material and what might be regarded for any specific type as "manufacturing quality," but also it is dependent upon thickness in a manner that is not too obvious. The relationship is certainly not always an inverse linear one. In many cases it will be seen that permeability increases with thickness for the same material, that is, increasing the thickness of membrane does not provide an added barrier for resistance to moisture transfer. While no laws have been derived, the following broad statements can be made on the basis of extensive practical tests, and said to apply to the majority of materials:—

(a) In thinner gauges, the rate of passage of water vapour through a material increases with increase in thickness.

(b) For thicknesses above an optimum value, which varies from material to material, the rate of penetration may remain constant independent of thickness, or may decrease and be approximately inversely proportional to this thickness value.

The values given for the waxed paper, bituminized papers, etc. (see Tables 1 and 2, Jan., 1941) illustrate this, although, of course, many more values than space here permits are necessary to be convincing. The suggested explanation for this phenomenon is illustrated in Fig. 9. This depicts the moisture transfer process as largely a surface phenomenon. On the high humidity side W there is a relatively high concentration of water w on the material surface; on the low humidity side D there is a relatively lower concentration d. These surface adsorbed films tend to maintain equilibrium with the respective atmospheres with which they are in contact, but additionally, so far as the nature of the material will allow, strive to attain equilibrium with one another. The inter-

Table 7.—Laboratory Characteristics of Finishing Media Used for Tests in Table 5.

Number and Type	55 Cellulose Brushing Lacquer	56 Tung Oil Varnish	58 Bituminous Paint	57 Glyptal Varnish	61 Cellulose Spraying Lacquer
Compositional per cent.:					
Volatile spirit (loss in wt., 3 hrs. at 110°C.)	89.5	63.5	51.8	64.5	86.5
Total solids	10.5	36.5	48.2	35.5	13.5
	100.0	100.0	100.0	100.0	100.0
Physical:					
Specific gravity at 25°C.	0.905	0.870	—	0.992	0.895
Viscosity, centipoises at 25°C.	360	195	—	25	360
Drying time, hours — Surface	¼	3	1½	3	¼
Drying time, hours — Hard	4	5	6	24	4
Melting point of bitumen base, ball and ring °C.	—	—	72	—	—

Table 8.—Characteristics of Polystyrene Lacquer.

Composition per cent.:	
Polystyrene (15/20°C. polymer)	8.5
Plasticizer (No. 1254 Arochlor)	1.5
Benzene	90.0
	100.0

Table 9.—Laboratory Characteristics of Shellac Spirit Varnish Used for Test Sample No. 60.

Composition:	
Industrial methylated spirit (64 O.P.)	51.5%
Orange shellac	48.5%
	100.0%
Quality of shellac base:	
Ash on incineration	0.08%
Iodine value (WIJS)	16
Wax and resin:	
Petroleum ether soluble matter	5.8%
Acidity (mgms. KOH/gm.) of extract	68
Insoluble matter in methylated spirit	0.5%

vening mass of material serves as the vehicle for this last process, and the quantity of water V held in it is proportional to its thickness. With the gradient W to D, the film d evaporates and is recharged from V. The greater V the more rapid is the replacement, namely, the thicker the material the higher the rate of permeation through it. Beyond a certain thickness V becomes large in relation to d, and then the rate of passage ceases to increase with thickness of material.

The reason for moisture permeation of fibrous materials is simple to conceive. Assuming good manufacture, the moisture vapour passes through the cellular structure of the fibre and through the interstices between the fibres, however tightly they may be packed. Experimental results show that degree of calendering and density have, under average conditions, little influence on rate of permeation, and from this it is assumed that rate of passage through interstices and through the actual cellular structure is of the same order. Impregnation dependent upon the degree to which it is carried out more or less completely fills the interstices between fibres, but probably does not enter the cellular structure at all. Some influence upon rate of penetration results in consequence. If the impregnant itself (e.g., wax, bitumen) does not transmit water vapour, and if it forms additionally a continuous surface coating not broken through by fibrous particles, a waterproofing skin is provided that will only be broken at cut edges, sharp folds or superficially damaged areas. From these explanations can be seen the difference in moisture penetration properties of papers and of papers impregnated with wax or bitumen. Moreover, in comparing impregnated papers of similar nature over a narrow range of thicknesses (e.g., waxed papers from 0.001 in. to 0.005 in., or bituminized papers from 0.003 in. to 0.010 in.) it has already been pointed out that generally resistance to moisture penetration falls off as thickness increases.

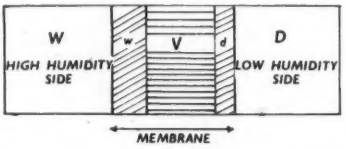


Fig. 9.—Diagrammatic representation illustrating possible explanation of anomalous—influence of membrane thickness upon moisture penetration.

Two possible additional reasons for this are (1) more complete impregnation through the thickness of the material occurs in the thinner gauges, and (2) there is generally more tendency for a continuous surface film of impregnant to exist on the thinner materials than on the thicker ones.

Table 10.—Laboratory Characteristics of Low-consistency Cellulose/Synthetic Combination Lacquer.

Composition per cent.:	
Volatile spirit (loss, 3 hrs. at 110°C.)	78.5
Total solids	21.5
	100.0
Physical:	
Viscosity at 25°C. (centipoises)	200
Specific gravity at 25°C.	0.934
Diluted 50/50 for spraying with thinners:	
Ester (butyl acetate)	21%
Hydrocarbon (coal tar naphtha)	61%
Butyl alcohol	18%
	100%
Specific gravity of thinners	0.874
Viscosity of 50/50 mixture at 25°C.	10 to 15 centipoises

In the case of coated materials (e.g., the so-called "oiled" or varnished silks and the proofed "viscoses"), waterproofing is determined by the presence of a continuous surface layer or coating of varnish, lacquer or other material which in itself is relatively impermeable. Thus the silks employ linseed oil, or preferably a china wood oil, varnish to give a flexible coating, and to render this efficient the base fabric is fixed sized with a selected starch base material. The varnish forms a layer upon this, and is thus enabled to exhibit to the maximum its own impermeability characteristics, because the size "fills" the surface pores of the fabric and prevents fibres from protruding through the varnish layer.

These cases are diagrammatically illustrated in Fig. 10.

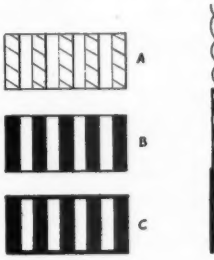


Fig. 10.—Diagrammatic Representation of: A, Plain paper; B, Impregnated paper; C, Impregnated and coated paper; D, Section of fabric cloth; E, as D, sized; F, as D, sized and varnished.

In the case of plastics (e.g., cellulose acetate, Pliofilm) and the regenerated celluloses, a gel or cellular structure must account for moisture penetration, and the nature of the material and its mode of fabrication explains the differences existing between one plastic and another, or between the same plastic produced in different ways. Finally, the case of metal must be noted, since this was quoted early on when talking of a material to use for "blank" tests. Porosity in casting is well known and is a function of shrinkage or expansion during solidification of the molten metal, and upon pressure exerted during casting, particularly in filling intricate shapes. But for the metal diaphragm for a blank test, sheet material is used, and this has been subjected to much rolling and reduction in cross section. The structure is, therefore, one of closely packed solid crystals, and it will be impermeable to fluid permeation.

From the permeability data presented, comparative numerical values can be derived by taking selected portions of the period of exposure. By calculating the ratio of the average weight of water permeating any given material to that for the blank test with no membrane, an average moisture-proofness or "impermeability" number is obtained. The procedure is arbitrary but not altogether empirical, and it furnishes a usefully concise method of expression of this property of "moisture-proofness."

Returning now to the other criteria for wrapping materials, these can be briefly dealt with. Cost varies widely, with perhaps rubbers and varnished fabrics the most expensive, and papers and treated papers at the other end of the scale. All are reasonable. Further, since the various plastics can be used in much thinner gauges, they often become on a covering capacity/cost basis as economic as, or even cheaper than, the paper materials. All the plastics, that is, cellulose acetates, regenerated celluloses and Pliofilms, respond to packaging methods of manipulation, printing, etc., as well as do the orthodox papers. The bituminized papers and rubbers do not offer the same flexibility for colour, pattern and print. The plastics, too, yield everything desired with respect to transparency and colour. The regenerated cellulose films possess high bursting strengths, superior to the other plastics of similar gauge. They possess excellent tear resistance. The 0.0005 in. acetate is poor, but the usual packing thicknesses are good, but not comparable with the regenerated celluloses for tearing strength. The Pliofilms exhibit a poorer order of strength, but service has apparently shown this to be satisfactory.

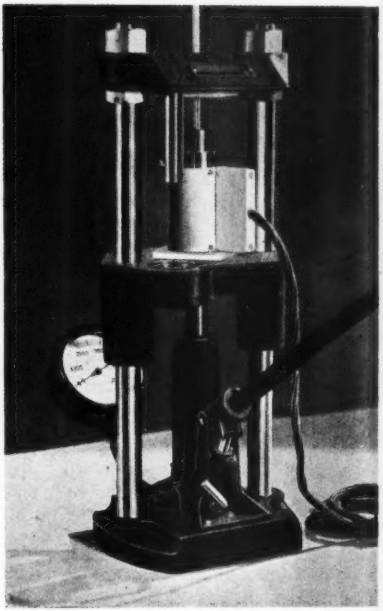
(To be continued)

Specimen Mountings

THE adoption of plastics as mountings for metallurgical specimens for physical examination has already been commented on in these pages. While the early specimens were produced somewhat amateurishly in physical laboratories, the process has now developed so far that the better-known of the instrument makers are offering excellent plant for production. One of the most modern is that by Adolph Buehler, N. Lasalle Street, Chicago. On the right is shown their AB Specimen-Mount Press. This is fitted with an improved jack and handle and has enjoyed wide acceptance in metallurgy. Carefully designed and sturdily built to give long service, over five hundred AB Presses are in daily use. Black synthetic resin or Transoptic mountings can be made easily under heat and hydraulic pressure in 1-in. or 1¼-in. diameter moulds.

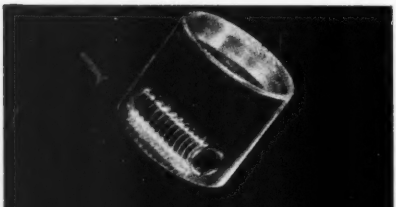
The hydraulic capacity is 5,000 lb. The 5½-in. by 8-in. sliding platen fitted with insulating plate has an 8-in. clearance.

Perfect adherence; absence of relief polish, margins, or crevices; usefulness in extreme edge studies; mountings in black and transparent media with resistance to reagents; convenient uniformity in size and shape for handling; economy of time, and ease with which the AB specimen mounting technique is achieved—all contribute to the popularity of resin mounting with the AB

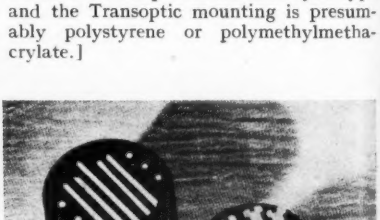


Specimen-Mount Press. Synthetic and Transoptic specimen mounts, to which the above comments apply, avoid the differential etching action encountered with fusible alloys in the older melting-pot and ladle technique.

[EDITOR'S NOTE.—The synthetic resin mentioned is of the phenol-formaldehyde type and the Transoptic mounting is presumably polystyrene or polymethylmethacrylate.]



Examples of Transoptic and—



—phenolic resin mountings.

World's Industry Employs Plastics

GENERAL ENGINEERING

Stresses in gear teeth constituted a difficult problem for the investigator. Development of the photoelastic technique has, however, simplified the issue. Dolan, in his research upon the influence of the fillet radius at the base of gear teeth, employed models cut in ¼-in.-thick polished plates of Bakelite (BP 61/893). Plates were annealed after rough sawing slightly oversize from the plate. Immediately after annealing they were machined to finished size with light cuts and tests were completed within a few hours after machining. No appreciable residual stresses or edge effects were present in the models tested. Calibration beams used for determination of the fringe stresses were cut from the rear portion of the model after tests were completed. Fringe photographs were taken in monochromatic (mercury green) light. A detailed account on the annealing of photoelastic Bakelite and the resulting effect on its physical and optical properties has recently been given by Lee and Goldstein, of Cornell University (Applied Physics 1941, p. 623). The annealing procedures were studied with the aid of a special oven and a straining frame set in a constant-temperature testing chamber. Samples were fitted with longitudinal and lateral extensometer and the photoelastic effect was observed with the aid of a Soleil-Babinet compensator. Annealed, ground and polished plates of Bakelite (BT-61-893) were cut into a number of samples of equal size. Results were based on average readings from a number of samples. It was determined that the properties desired for a material in photoelastic investigation were: low optical coefficient for stress and low physical and optical creep values. The best compromise in these properties is obtained by annealing between 240 and 250 degrees F. for a time just sufficient completely to remove all initial stress. Samples ¼ in. thick, for example, are placed straight away in an oven pre-heated 240-250 degrees F., soaked for one hour, the oven being then allowed to cool with the specimen in it at a rate of approximately 15 degrees per hour. Photoelastic stress distribution in bars of various shapes, and machined and constrained in various ways, have also been described by Frocht and Leven, whilst Weller describes a new method for studying photoelasticity in three dimensions by using scattered light. Murray studies vibration by the same technique. The polariscopes used in these later researches were equipped with polaroid polarizers.

CHEMICAL

Tubes and fittings in polyvinyl chloride have recently been made the subject of seven standard specifications, D.I.N. 8061-8067, by the German Standards Association. It will be recalled that, in Germany, resins on this base are marketed under the names Vinidur, Igelit, P.C.U., Mipolam and Decolith. The first specification is devoted to data on physical properties, resistance to chemical attack, permissible stresses and practical details as to the forming of parts in the resin. Tube

dimensions are given for 17 different internal diameters between ¼ in. and 6 ins. Three different wall thicknesses are pressures of 0.5, 2.5 and 6 atm. Elbows are provided for inside diameters from ¼ in. to 2 ins. Screwed fittings and flange fittings are provided for any diameters from ⅜ in. to 6 ins. Loose flanges may be of mild steel, light metal, hard paper, plywood, or of suitable grades of polyvinyl chloride resin (see V.D.I. Zeit, Vol. 85, p. 780, 1941). Quite naturally it is to be anticipated that the drafting of these specifications will do much to increase the attractiveness of plastic components as opposed to corrosion-resistant metal fittings for certain types of chemical plant, for which hitherto structural replacements have generally been immediately available only in the traditional materials. In this way considerable economies can be effected in changing over from one material to another, and field tests on suitability of plastics for certain components can be made rapidly.

ELECTRICAL

Creep currents and the paths taken by them on plastic insulators have been investigated by Staeger and Siegfried, whose work is reported in Schweizer Archive f. aug. Wiss. No. 4, 1941. In spite of the large amount of research done upon this problem, no clear inter-relation has been shown to exist between the formation of creep paths and actual resistance to creep of the material. The problem is complicated by the fact that the insulating material consists of a mixture of resin plus filler. In the research referred to, transparent sections of phenolic and aniline-formaldehyde resins were used. Microscopic investigation showed that the structure of these materials is not uniform, but that boundary zones exist between regions of different structure; into these boundary zones any electrolyte present may wander; it is from these zones the creep paths are started. The type of path formed depends on the electrolyte which happens to be present and on the structural condition of the material; atmospheric humidity was found to be of precise importance and when humidity was low no creep paths could be observed. The authors consider creep as a corrosion phenomenon and suggest that resistance to creep may be compared with corrosion resistance. Sixteen different materials were examined and the account deals with testing equipment, measurement of surface resistance and microscopic investigation.

FANCY GOODS

Lighter and more decorative uses of transparent foils for fancy goods and fancy packings have largely been submerged by war requirements, but, for all that, development is going ahead. Among the newest transparent foils on the market are those based on polyvinyl chloride and these are made the subject of a very detailed review by Beck in a recent issue of Kunststoffe. Polyvinyl chloride foils are supplied in two grades—thick foils 0.3 to 1.0 mm. and thin foils 0.02 to 0.1 mm. thick. The foils combine all the properties associated with polyvinyl chloride resins: extreme resistance to chemical attack, entire freedom from smell or taste, utmost resistance to discoloration or breakdown by light or age, impermeability to water vapour. The foils dealt with by Beck are of a red-brown colour, transparent and of high mechanical strength. They are claimed to be superior to the weather-resistant grades of regenerated cellulose. Thick foils may be worked up and developed similarly to tinplate; for example, food cans can be drawn up from them. The

operation is carried out at room temperature. The material is said to be eminently suitable for pharmaceutical and cosmetic preparations. The only limit for its application is constituted by its relatively high price which renders it uneconomical for cheap lines. Thin foils may be obtained in colourless form and are sold under the trade name Luvitherm. The obvious field of use for this quality is as an external wrapper for paper and cardboard containers and for packaging generally.

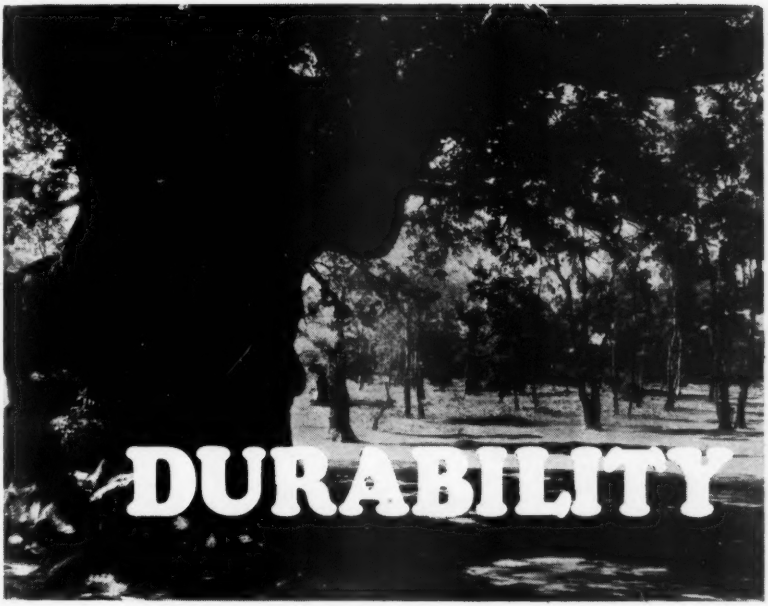
MISCELLANEOUS

Orthopædic equipment is envisaged as the chief avenue of consumption for a new material to be marketed under the name of Panplast. A wide range of applications, however, is possible for the new material. It consists of an impregnated textile fleece, containing, as essential constituents, natural wool, together with casein wool and various vegetable and synthetic fibres. The impregnating medium is based on nitrocellulose and synthetic resins, containing regulated amounts of plasticizers and fillers. Panplast is obtainable in the form of tough sheets of various thicknesses, and in sizes up to 30 by 40 ins. It may be shaped to any desired form. No attempt is made to give the material the appearance of artificial leather, as "graining" tends to lower mechanical properties. Orthopædic devices of this material may be lined with chamois leather or with thin, harder leathers. First operation in the manufacture of Panplast is the working up of the fleece; fibres and materials are carefully selected and carding must be absolutely uniform. Temperature and operating times are minutely controlled in the felting, dressing and washing processes. Second operation consists of impregnation in a continuous, combined dripping and drying plant, from which the material emerges, and passes to a hot-air drier from which volatile solvents are exhausted and recovered. The impregnation process is so controlled that mutual adhesion of the fibres is assured, and, at the same time, each separate fibre is protected against absorption of moisture; nevertheless, the mass is not rendered absolutely impermeable, and capacity for transpiration is maintained. Specific gravity of the material is 0.5-0.6; it is thus lighter than the leather used for general orthopædic equipment (S.G. 0.8-1.0). It is much lighter than duralumin (S.G. 2.8+), but is somewhat heavier than poplar (S.G. 0.4-0.5). For trunk and spinal supports, less springing is needed with the new material than with ordinary textiles, and it is considered possible to use light-metal stiffeners. Artificial feet in Panplast are 30 per cent. lighter than those in wood, whilst artificial arms without mechanism are 50 per cent. lighter. The weight of complete artificial legs compares with that of similar limbs in light metal. Tanned leather, commonly used for all these purposes, is a bad conductor of heat and is of an unsuitable degree of porosity. It absorbs moisture and has a chilling influence. The new material is said to have low heat conductivity and higher porosity than leather, but its affinity for water is lower. The durability of Panplast in use is high, as it is not attacked by perspiration, which is allowed to evaporate quickly. The material gives rise to no decomposition products of an irritating nature, and does not reduce skin activity. It is suggested that interchangeable sockets of Panplast might, in certain cases, be fixed to light-metal artificial legs. Observation has confirmed that the composition of the material does not alter in use and that it is perfectly safe from the hygienic standpoint. The material may be plastic deformed by treating it for three-four hours in solvent vapour. After softening Panplast becomes perfectly plastic and, in this state, may be permanently formed to any desired shape, which is kept after drying out for two hours at room tempera-

ture or half-hour in hot air. No shrinkage allowances are necessary. Local modification of shape after moulding may be achieved by softening at the required point by the application of solvent. Besides its orthopædic uses, Panplast would appear to have some future in military equipment as it is free from the undesirable property of swelling in contact with water. A special quality is used as a thermal insulator for tropical outfits. A detailed account of this material is given in Kunststoffe, Vol. 31, p. 68 (1941).

Foils may be produced from a water-containing gelatinous masses of polysacharides, according to Swiss patent 207,764 of the Papierfabrik Oberschnitten W.L. Monfang A.G. The composition is passed through a machine which spreads the masses on a continually moving band, which itself is covered with a separating layer, such as hard paraffin wax. This is continuously renewed on removal of the foil, which has accrued after removal of moisture. **Catalogue of about 170 different proprietary brands of plastics,** classified according to their special properties, such as corrosion resistance, impact strength, resistance to inflammation, light transmission, etc., is given in the directory of materials, supplement to "Machine Design," October, 1941. Besides plastics and other non-metallic materials and metals, are listed a further compilation of names and properties of new plastic products, as given in "Machinery," New York, October, 1941. Here about thirty brands of plastics are named. Amongst these is a new product, "Pasul Basolit," which is employed as an impression-checking material of high sensitivity, very light and not subject to shrinking. It will show the finest markings on a form or die. It is said to be particularly adapted for checking impressions of forgings and die-casting dies. It may be used on woods because of its dimensional stability.

Drawing office equipment, such as set squares, curves, T squares, rules and the like, is not commonly classified under the heading of precision instruments, although, in fact, it is to this category that they belong. They are also subjected to very heavy wear and to no small amount of rough usage. Until recently, equipment such as this was commonly constructed of thin hardwood, plywood, or of celluloid. The first of these tends readily to split and break, or develop irregularities on working edges; celluloid, otherwise ideal and in no way rendered unsuitable because of its tendency to turn brown with age, possesses the serious fault of dimensional instability—even if warping do not occur, angular changes may take place. The use of laminated hard paper for such purposes as this possesses many advantages. The materials are harder than wood or celluloid, and are not readily cut by means of an ordinary knife. Edges and corners resist damage and have a sufficiently high impact strength to bear dropping on the floor. From the production standpoint, too, these materials have a great appeal; complete instruments may be constructed in one piece, so that once the tool set-up is fixed, troubles of joining and alignment do not occur. With highly irregular objects, such as curves, wood is particularly disadvantageous as cross-grain runs invariably tend to split off after a little use. Naturally, this does not occur in the case of hard paper, which, in sufficiently thin section, is, in fact, highly flexible. An æsthetic advantage of the new materials lies in the fact that indian ink wets them only with difficulty and causes no permanent staining. It might be argued that these plastic materials have a slightly higher weight than wood, but, in point of fact, their specific gravity is no greater than the older types of ebony. Not only in the drawing office, but in the shop, too, equipment in laminated plastics has everything to recommend it. It cannot dent or receive unsightly scratches in normal bench use, and, again, is not likely to be torn by contact with a scriber or knife. Recently in U.S.A., a T square has appeared on the market in which the head consists of a black laminated phenolic resin $\frac{5}{16}$ in. thick, whilst the blade in Escolite is transparent, non-brittle, light-fast and stable.



Symbolic of endurance, this grand old tree, the Queen, or Major, Oak has stood in Sherwood Forest for so many years that there is no authentic record of its age.

The quality of endurance is found not only in aged things. Modern plastic materials—although so light in weight—possess it to a remarkable degree.

Skilful and untiring research, the employment of raw materials of the highest quality and complete supervision at every stage of manufacture have given maximum durability to the products of I.C.I. (Plastics) Limited. These include "Mouldrite" phenol formaldehyde type and urea formaldehyde type powders, resins and syrups; "Perspex" acrylic resin in sheet form; "Diakon" acrylic resin in powder form; "Welvic" polyvinyl chloride compounds, and nylon monofils.

I.C.I. (PLASTICS) LTD.

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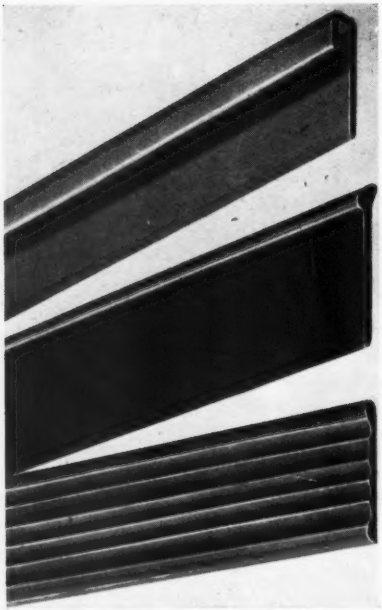
Sales offices at Mill Hill, London, N.W.7; Oldbury, near Birmingham; Alderley Edge, Cheshire; Bristol; York; Newcastle-on-Tyne; Glasgow; Belfast.

EXTRUDED PLASTICS

make rapid strides



Samples of plastic extrusions from acetate flake furnished by the Hercules Powder Co. The extrusion rate on one sample is given as 750 ft. an hour from a single inexpensive die.

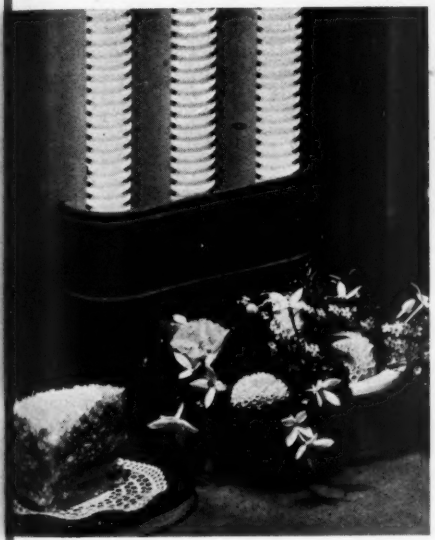
EXTENSIVE use for extruded plastics is being found by American manufacturers, and several companies, some of which have supplied only moulded plastics heretofore, are now equipped with machines for the extrusion of plastics. In many cases plastic extrusions have taken the place of metal formerly used in extruded or rolled sections. Such use would be increased still further were it not that a great shortage of plastics has developed. Plastics manufacturers have been handicapped in increasing the supply of plastics in some cases by a shortage of the raw materials required in making the plastic itself and in other cases by inability to secure the metals required to build new plants and new equipment needed for turning out larger supplies of plastics.

Although there is a large use of extruded shapes (often referred to as "mouldings," although the shapes are

Chair with back rest made from strips of Tenite II (cellulose acetate-butyrate) extruded by Detroit Macoid Corp. Chair made by Ypsilanti Reed Furniture Co.

The extrusion of plastics began much later in the U.S.A. than in Gt. Britain. The last two or three years have, however, seen many important developments as the photographs published here amply show.

(Right) Coils of extruded Tenite for application over fluorescent light tubes afford a means of varying the colour of the light. (Left) Fluorescent lighting fixture having coils of extruded plastic over the tubes. Alternate coils are in different colours.



not moulded), rods and tube are also extruded and there is a growing production of filaments of thread-like fineness much used in manufacturing special braids, trimmings and even fabrics. The filaments are much coarser than those characterized as "rayon" and are usually much larger in diameter than the yarns which are produced by spinning of rayon filaments.

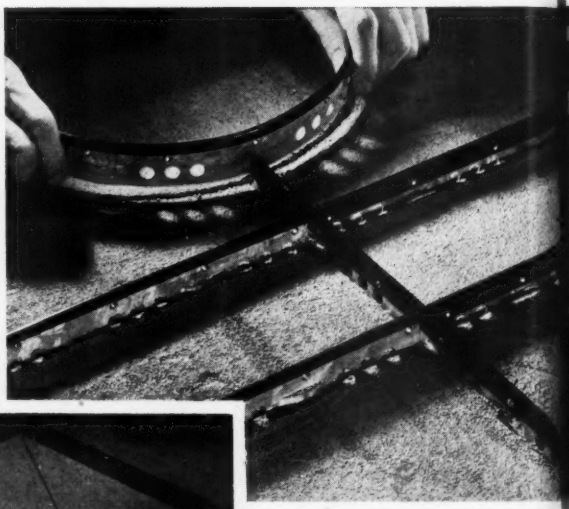
Most of the thermoplastics can be extruded, but cellulose acetate has probably gained the widest use, partly because it is lowest in cost (with the possible exception of nitro-cellulose) and extrudes readily. Cellulose acetate-butyrate, commonly costing only a cent or two per lb. more than the "straight" acetate, is also much used, as are several vinyl plastics. Nitro-cellulose has long been extruded, of course, and extruded forms, especially tubing, are still employed, especially for pen and pencil barrels. The flammability of nitro-cellulose limits its usefulness however. Ethyl cellulose can also be extruded, but is not widely employed.

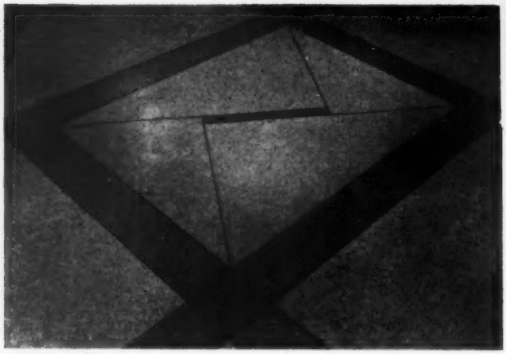
Although the primary uses thus far have been in civilian applications, as distinct from war uses, they have indirectly benefited war preparations in replacing metals

Table covered with linoleum and edged with extruded cellulose acetate. The apron below the edging is also extruded—by R. D. Werner.

needed for war applications. Recently, however, there have been some direct war uses, especially in aircraft, where some conduit for electric wires has replaced aluminium or other metal tubing.

An important development recently announced by the Dow Chemical Co. is the production of Saran tubing, for use in place of copper and other metals. The material is semi-transparent, highly resistant to chemical attack, and is said to be usable where stainless steel and other nickel alloys have been required before, except that it is not suited, of course, for high temperatures or very high pressures. The material is unusually tough and resistant to moisture, as well as to many solvents, brines, acids and alkalis. Use for short periods at temperatures of 250 to 275 degrees F. is said to be permissible. The tube is available in $\frac{1}{8}$ to $\frac{5}{16}$ in. outside diameter and in wall thickness of 0.030 to 0.062 in. It is claimed that the tubing can be joined by standard S.A.E. and other flared tube fittings. One brass company is reported developing special fittings in which the fittings are and remain out of contact with liquid passing through the tube. Tube joined with what is called a "B" Parker Standard Tube Coupling is said to have withstood a pressure of 1,500 lb./sq. in. without leaking. In fatigue tests the tube is reported to have withstood flexing through a 15-degree angle over 2½ million times without failure, whereas a copper tube failed in the same test after about 500 cycles. This would indicate great superiority to copper where excessive vibration is encountered. Announcements do not indicate what effect low temperatures may have, but if the effects are not serious uses in aircraft for certain purposes appear possible.

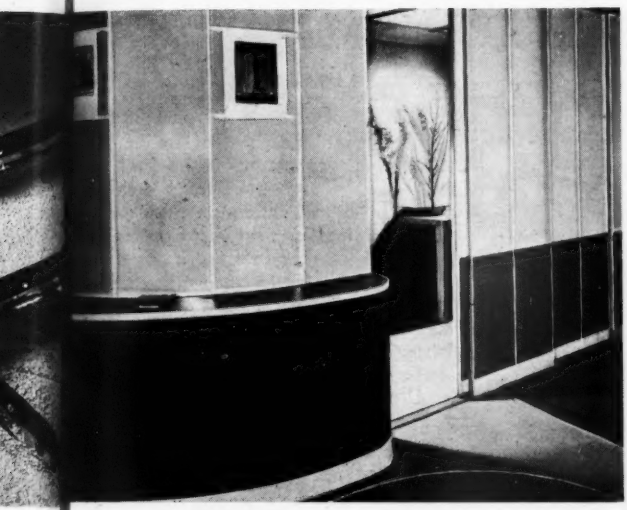




(Above) In laying terrazo floors, slabs are commonly divided by brass strips, but the shortage of brass has led to the use of galvanized steel edged with extruded Tenite strips $\frac{5}{32}$ in. thick. Extruded Plastics, Inc., produces the plastic extrusion.

(Left) Finished terrazo floor incorporating plastic strips between panels.

Accompanying illustrations give some indication as to certain uses to which extruded plastics have been put. Edging for tables, counters, sinks, showcases,



Translucent panels of plastic are held in place in this ultra-modern New York office by extruded strips of Tenite. Other strips in white are employed for the edge of the counter and as a dividing strip between the coral linoleum strip and the carpet.

glass enclosures, and the like accounts for a considerable production. Unlike metal, no polishing, plating or other applied finish is required, and this alone results in an important saving, often making the extruded plastic cheaper as well as better, and providing a range of colours which are attractive and permanent. Smoothness, ease of working and freedom from corrosion are important assets. Automobile manufacturers have been large users, but the greatly reduced schedules of passenger-car production has limited applications in that direction. All such uses have been confined to interior decorative parts, some of which are applied over metal strips, which are hidden and provide projections for fastening to metal panels or other backing. There has been some use in which metal has been applied in the front of C-shaped or channel sections to give special decorative effects, but such use is now affected, of course, by metal shortages.

Application in furniture is increasing and there are other uses for lighting and architectural work. Narrow extrusions have been woven into seat coverings and similar strips wound in a helix over mandrels have gained some use. It is a simple matter to extrude almost any shape. Tubes which are fluted outside have been made, and it is possible to produce several diameters from a single die by merely varying the speed of the belt on to which the extrusion is discharged. If the belt speed

(Continued on page 30)

Some of the extruded acetate-butyrate sections produced from Tenite II by Detroit Macoid Corp. The wider extrusions have been widely used as interior trim on motorcars.

THE POST-WAR HOME

Its Interior and Equipment

We have pleasure in reproducing herewith one of a series of twelve papers that have been read by authorities before the Royal Society of Arts. We reproduce it as a corollary to the articles by Mr. Kennedy and to indicate how the architectural world is tending more and more to regard the products of our industry as important to future developments. The following, under the title of "The Contributory Industries: What are they, and how can they help re-employment?" is by Howard Robertson, F.R.I.B.A. Although of a general nature, it contains many facts about the building industry that plastics technologists should know.

IN a normal building year, just prior to the war, the annual output of the building industry in the form of completed building work was somewhere in the nature of £425 million. Of this sum, about £300 million was spent on domestic buildings. That shows the very important role which domestic building plays in the national economy. Building is the second largest activity in this country, agriculture being the first. But building is the largest male-employing *industry*. This factor of male employment is significant in the sense that the industry covers probably the highest family rate of any industry. It employs annually some 1,450,000 workpeople, exclusive of the ancillary trades dependent in greater or less measures on it, which employs perhaps another 1,550,000. So it is easy to see the force of the belief, long held in the United States and in pre-war Europe, that building is a key economic and social factor, and that *quand le bâtiment marche, tout marche.*

The Contributory Industries

The home-building section of the industry is largely supplied by the same contributory industries as the other sections. Certain lines of manufacture are schemed directly to supply the requirements of domestic building. But the bulk of the suppliers are making all sorts of equipment for other types of building, too. Very few, if any, concentrate on domestic equipment only. So that the supply of this field is interlocked with general questions of manufacture, and any policy which affects the design and types of building equipment generally will affect what goes into the house and flat. It is necessary to realize the implications of this; which are that steps taken to standardize, or rationalize, methods of construction, materials and types of equipment throughout the industry will react directly on the designing and building of post-war homes.

The Sociological Problem

There are two things which are of uncommon interest to all the people of this country. One is the pay envelope, and the desire for some assurance that it will never be empty. The other is decent living conditions for the family and the children.

Money in the pay envelope depends on employment. And one of the biggest tasks of reconstruction planning is to ensure an immediate resumption of work. To do this implies that plans and schemes will be ready. For it takes months, and sometimes years, to plan. Layouts must be in existence and types of plan for dwellings available. These types will be nearly useless unless they are based on possibilities of execution; that is to say, on the sort of labour and material likely to be available.

The type of building goes hand-in-hand with the problem of equipping it, this again being dependent on production possibilities. But before production can be put into top gear, designers must be satisfied that they are producing what people need and want, within the limits of the post-war economy.

So we come back again, as always, to the sociological question. Town planners and architects are instruments for satisfying a human urge for accommodation. And by that is meant not only houses,

but schools of all types for the children, places to meet and play in, cinemas, pubs, cafés, open spaces, shops and markets. The key to proper planning is the development of corporate centres and communities of which the home is the nucleus. Any advance in design should be integrated, the home and its surroundings advancing in line.

The Principles of Home Design

Before the equipment of the home, and the industries supplying it, can get under way we have to be satisfied that the principles of home design are right. Domestic architecture has been concentrated upon by such a number of first-class brains that it would appear almost impossible that there should be a field for further research. But, actually, there is still a lot to be determined, both as to types and equipment. Can it be said, for instance, that the requirements for living of families have been fully analysed and met? Take the question of children; the child is entitled to its own space, to provision for playing, study and privacy. As children grow up the need for privacy increases. The parents have their own demands. Their bedrooms should offer privacy and quiet, and convenience of planning, and they should be soundproof. Bathrooms in some homes may be bathrooms only. But in others they may be expanded into utility rooms, where light household washing can be done. That may shock some people, but it is what a lot of working women would like. And if they like and get that, perhaps after all the bathroom will end up by being on the ground floor and not upstairs. "Retrograde," some may say. But if there is argument only over such points as these, it only goes to show that further research is wanted. At any rate, experience does show that our flats and houses are not soundproof, that they are often flimsy, that they are primitive in their heating, that they are rough and labour-making in finish, that their windows are not draught-tight, that their storage and cupboard space is insufficient, that more importance is attached officially to statistical dimensions (i.e., areas and cubes) than to actual utilizable space, and that the provision of equipment, particularly in the kitchen department, has remained largely stationary during the past years and is very much below, let us say, American standards.

It is easy to criticize. The main reason why the standards are low is that it is uneconomic to make them better. The average pay envelope will not run to a thoroughly well-equipped home, which must be subsidized or otherwise carried on the back of the ratepayer. That is a matter for Government policy, but a vital one. For it is of little avail to design for better standards, only to find that they are hopelessly cut down.

A partial and technical answer is provided by research into more economic methods of building and equipment; but it must be realized that it is not a complete one. The shell of a house represents, say, 40 per cent. of its cost. The equipment, cost of land and other charges all go to make up the rest. Most improvements commonly suggested to-day are in the direction of better standards of building and finishing, the provision of more and more useful devices. They all go to increase the cost. If present-day economics prevail and worsen, only the wealthy will be able to afford what modern technique can offer. This is a big and separate problem.

The Raw Materials

Into equipment enters nearly every branch of industry. Take materials, such as iron, steel, copper, lead, zinc, aluminium; plywoods and manufactured boards of plaster, wood pulp, asbestos; materials with a basis of rubber, asphalt, tar, jute; the plastics, an enormous actual field and still more so potentially. Then, of course, the major heavy contributories, such as the clay industry, the cement and concrete industries, the metal industries, the glass industry, all concerned in both the shell of the house and many items of its finishing. Of course, there are also many existing and new types of industry which are struggling along in the equip-

ment field or are developing partly on account of war demands. And there are great industries, most of which are represented by powerful associations, such as electricity, gas, coal, chemicals, which have an enormous stake in home building.

Standardization and Costs

One way to cheapen costs is to mass-produce, which means a reduction in choice of types and concentration on the remaining basic models. Take the reduction in types of bricks, for instance, which in different parts of the country have been made through long custom to slightly varying sizes, so that the bricks of one district will not bond with those of another. Then again, metal windows, where some 40 different patterns have been available. The Ministry of Works and Buildings has set up a Department of Standardization, and its job is to ascertain the minimum number of types which can be applied to up-to-date building and persuade the manufacturers (and the designer) to concentrate on those. The British Standards Institution has for years been working out standard specifications for all sorts of building components down to nuts and bolts and screw threads, to set up a reliable standard for these things and eliminate wasteful redundance. There are also some technical bodies which have set up standard specifications, which have become officially recognized. And all the professional and technical bodies co-operate with the British Standards Institution in this work, which will have to go on and even be widened.

What will undoubtedly occur, and is already in the offing, is the widening of standardization into actual methods of building. This may take the form of a code of building practice, perhaps replacing or unifying existing regulations and by-laws, and setting out what is sound, minimum construction. Properly worked out, it may reduce costs, because present regulations insist on things which are sometimes quite unnecessary and, therefore, pure waste of money. But the purpose and machinery for such a code require careful scrutiny before the principle is accepted.

Such standardization should not be aimed at regimenting design, but at simplification of methods. It might logically extend into setting up standards for equipment for houses, and in that way there should become available more items at a lower cost.

Many of these equipment elements are already prefabricated. And that brings us to the question of prefabricating many more parts of the home, including whole items like kitchens and bathrooms, and even the shell of the building. So far, prefabrication of walls, roofs and floors has only had limited success, even in America. But for certain types of small houses it might be taken much farther and offer a solution to the need for immediate post-war housing. The building industry will be hard pressed; on the other hand, there will be numbers of highly skilled workers in aeroplane, tank and other factories available for jobs. The plants employing them might turn over to housing and manufacture sectional parts of houses to be assembled by the men of the building trade. Incidentally, such houses may have less than the normal life, and present methods of home financing may have to be revised in consequence. The making of these parts would thus become one of the contributory industries, along with the others which we know. The whole scheme demands preliminary research in a big, but disinterested, way, and the best start would be for the professional bodies and the trade associations to get together; this, in fact, has already been begun between the Royal Institute of British Architects and certain trade associations.

Prefabrication Problems

The industries contributing to home building can help re-employment after the war by increasing this collaboration. Designing will have to proceed on the one hand and methods of production on the other. It is likely that in this country the permanent home of the future will be

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Rubber Balloons Aid House Construction

One of the most astounding developments in house construction is that recently reported from America, utilizing rubber fabric under pressure as a base for form building. This process, the elements of which are already familiar to readers of "Plastics," for the production of cast resin statues and the hardening of laminated shapes for aircraft manufacture, is dealt with at length in a recent issue of "Rubber Age." While the structures described are of concrete the methods employed will provide much food for thought, so that we have pleasure in abstracting herewith much of the notes.

A NEW economic, high-speed construction technique is being demonstrated for the first time on a Defence Homes Corporation project at Falls Church, Va., near Washington.

The new construction method employs the use of an inflatable rubberized fabric balloon, over which concrete is shot pneumatically to form the basic shell for the building. The balloons may be made in the shape of a hemisphere or in any practical size. Farm homes, stables, granaries and all other types of farm building, as well as city dwellings, can be built by this new process quickly and inexpensively.

The Falls Church Defence Homes project is devoted to the production of attractive, inexpensive dwellings, each comprised of two hemispherical sections erected several feet apart and connected with a covered area-way divided into entrance hall, bath and kitchen. One of the hemispheres is divided by a wall into two ample bedrooms, and the other is a spacious living-room with fireplace. A surprising amount of closet space is obtained by taking advantage of the corner areas wherever walls are joined to the arc of the outer shell.

The first step is the preparation of a circular concrete floor, approximately 23 ft. in diameter. Spaced at frequent intervals around the perimeter and embedded in the concrete are steel hooks, which are used to anchor sections of small pipe bent to the same arc as the circular base's circumference.

The flat side of the uninflated balloon is laid out on the concrete base. Entirely

Front view of a completed house, built by the balloon method. Dome on right provides large living-room with fireplace; area-way in centre space for entrance hall, kitchen and bath; dome on left is divided into two bedrooms, approximately 10 by 14 feet.

Operator shooting concrete against the balloon form in the first step of actual house construction. The wire mesh is pulled out with a hook so that the concrete works behind it as well as over it, thus embedding the mesh in the shell.

around the flat side of the balloon is a series of eyelets, and these are tightly laced to hook-anchored pipes with stout cord to hold the balloon firmly in place. The balloon is now ready for inflation from an air line to a pressure of approximately 1½ lb. to the sq. in. When fully inflated the balloon is dusted with a compound to prevent concrete from sticking to it. The whole hemisphere next is covered with 2-in. 16-gauge welded wire mesh, to serve as a bond for the concrete, which is shot over the entire balloon to a thickness of approximately 1 in. by the gunite process. The frames for doors, windows and other desired apertures are fixed in place before applying the concrete, which can be shot around them, making them an integral part of the shell.

It takes between 2½ to 3 hours to shoot the concrete for the shell, and 24 hours later the balloon may be removed and set up for the next section.

The outer surface of the resultant inner shell is vapour-sealed with an asphaltic base compound, applied by stiff brush, and the structure is ready immediately for application of insulation. Insulation in the form of ground pulp in an asphalt emulsion may be sprayed on to a thickness of approximately 1½ ins., or a specially prepared blanket of the same thickness of balsam wool may be applied in even shorter time.

Over the insulation again is placed a covering of wire mesh, and the final coat of concrete is applied to a thickness of between 2 and 3 ins. and then painted.

Gunite mixture consists of standard Portland cement and sand mixed dry and carried from the mixer by a conveyor into an air lock known as a cement gun. The mixture is forced through rubber hose to the nozzle in dry form. Another hose brings water to the nozzle and hydration takes place as the concrete ingredients are emitted together. The balloons are of tough rubberized cotton fabric construction, quite similar to that employed in the production of automobile tyres.

Vern D. Case, head of the construction company, estimates that concrete houses identical or similar to those now being erected at Falls Church could be produced at the rate of 100 in 60 days or 200 in 90 days, using only four balloon forms in the construction cycle.

THE POST-WAR HOME

(Continued from page 26)

a permanent building. But it will have to be capable of being built more quickly and should be designed to provide more for the money. Towards arriving at this, well-devised prefabricated standard elements would go a long way. Light, strong, fire-resisting floors; standard wall panels and supports; standard foundation bases for supports; standard roofing elements all cut to size and delivered; standard cistern, cylinder, hot water and heating units all in one trunk or casing, to be built into a standard space in the house; standard soundproof partition sections; standard windows, draught and soundproof, incorporating shades or shutters and ventilation grilles, and possibly heating elements as well. Standard kitchen components of sink dish-washer and refuse destructor, of refrigerator-cum-larder-cum-store, standard wall sections incorporating shelving, plate racks and dishcloth dryers. All these things and many more occur in houses; if they can be made in series they can be made in quantity and cheaply. Plans for them are necessary before post-war building begins.

Side-by-side with this, industry can work on the so-called prefabricated house, an interim solution, which may be necessary. The research entering into this problem will be invaluable when applied to what we hope to see later, namely, houses of much better standard than we have ever had before.

Let us end as we began, by statistics. After the war some 3,000,000 people, amounting to nearly 25 per cent. of the insured population, are going to be dependent on building. It is worth while taking trouble to prepare for them.

INQUIRIES AND ANSWERS

(In Which is Included General Correspondence)

IMPORTANT NOTICE: If inquirers wish to receive replies by post, a stamped and addressed envelope must be included in their letter. Unless otherwise stipulated, it is understood that the submission of a problem to the Editor permits its publication in this journal.

Moulded Graticules

With reference to the above problem and the answer given to it in our January issue, we have received the following letter from one of our most distinguished contributors. He says:—

"May I comment on your problem of 'graticules,' although I do not want to make them and therefore cannot co-operate with your inquirer! I have provided cellulose finishes in various colours, eggshell matt, on metal dials especially for receiving scales by photo-printing processes. This seems irrevelant, but it stresses that accurate dial markings can be applied from a master in this way on nitro-cellulose films and therefore why not upon other and moulded plastics? In fact, I believe Metro-Vickers use this process on Traffolyte (amino-plastic). Could this not apply to your suggestion of polystyrene or methacrylate, even if the base material has to be pigmented?

"I also recollect that in one of the early Lorenz blind landing equipments the floating dial was an amino moulding and that it floated in paraffin oil; over a period of several months it was checked for stability with satisfactory results. In the same instrument we had to change fish-spine beads (ceramic) that were used for electrical insulation to plastic sleeving. Polyvinyl chloride stood up to the oil excellently, being checked on test (140 degrees F. day and cool night) over 18 months. Even highly plasticized cellulose acetate sleeving that was used temporarily stood up for a long period before becoming unduly hard. The tiny amino moulded buffer blocks on relays appear to stand up quite well in transformer oil although I have not had much experience with them yet. However, they are on service jobs and there would have been rejects by now if they had failed.

"I have had no experience with iso-butyl alcohol so that I cannot comment on its action.

"I just mention these points to illustrate that plastics do stand up to some of these unusual conditions. I am not plastics 'one-way minded,' but I do hate working ceramics, glass and the like, and though I have not had the doubtful joy of working mother-of-pearl, I can sympathize with the inquirer!"

E. E. HALLS.

[EDITOR'S NOTE.—The inquirer only mentioned iso-butyl alcohol. We added the words mineral oil. We should think that iso-butyl alcohol would attack most plastics.]

Trade Name

Our attention has recently been drawn to a plastic called "Kreosol." We shall be very grateful for any information on the properties of this material and the name of the manufacturer.

THE METAL BOX CO., LTD.
Acton, W.3.

[EDITOR'S NOTE.—We can trace no such trade name and suggest that there is an error and Koroseal is intended. Koroseal, as the inquirer probably already knows, is a polyvinyl compound made by B. F. Goodrich.]

Face Masks and Models

We shall be glad to know if you have any data concerning the properties and working of "Negocoll" which, we believe, was imported by Zuric, Ltd., before the war from Austria.

THE MERVYN SOUND AND VISION CO., LTD.
Teddington.

[EDITOR'S NOTE.—In our July, 1937, issue we published a fairly complete article on Negocoll and Hominit and their use in the production of face masks, models, etc. The compounds were probably

waxes or mixtures of waxes and special resins formulated by a Dr. Poller, whose methods were adopted in this country by Zuric, Ltd., New Malden. If the reader cannot obtain the issue referred to, he can see it at the Patents Office Library or at this office.]

Synthetic Resins and Water Purification

In the December issue of "Plastics," Vol. V, No. 55, an article, "The Purification of Water by Synthetic Resins," is given on page 234.

Please forward information whereby we can make contact with the manufacturers or suppliers of the necessary resin materials.

EDISON SWAN CABLES, LTD.
Lydbrook.

[EDITOR'S NOTE.—The article referred to dealt with those synthetic resins for purifying water as manufactured in the U.S.A., under the name of Amberlites, by the Resinous Products and Chemical Co., Philadelphia, Pa. This company has developed these presumably under licence from the British manufacturers of similar resins, the Permutit Co., Ltd., of London. Unfortunately, the British company does not appear to have given the matter much publicity; at least, we have received none. British concerns seem to lag far behind the Americans.]

Cigarette Lighters

We are anxious to try to find a firm which is manufacturing the new cigarette lighters, and are wondering if you can assist us to this end.

We are, if possible, trying to find someone in the Birmingham or Midland area whom we can contact personally.

JAS. HARRISON AND SONS, LTD.
Birmingham.

[EDITOR'S NOTE.—We wish we knew. Perhaps one of our readers will oblige. According to the latest information production has been put off for another month or so. A daily journal has recently stated: "Reason for the hold-up, a Board of Trade official explains, is the difficulty in getting plastic materials. Aeroplanes have first claim." We hope we shall not see the plastic lighter in war-time.]

Copper-covered Earths

We think it was shortly after war broke out that we read in "Plastics" a suggestion by the Editor that a considerable proportion of copper metal could be saved by fabricating a wireless earth of the large conical type out of synthetic resin or laminated material and spraying the outside with a copper film. It was suggested that the resin base would stand up well to corrosion by the acids in the ground and that after all only a thin film of copper is required to conduct electricity. We agree so much with this that we are inquiring whether you have carried out any experiments on the idea and whether anything has been achieved on a practical scale.

Manchester. J. S. AND CO., LTD.

[EDITOR'S NOTE.—Much to our regret nothing has been done. One large moulding concern was interested, but we have heard nothing further. Metal spraying on plastics can now be done so well that those practising it may think the matter worth while pursuing. As the reader probably knows, aluminium-sprayed resin-laminated sheet is now being widely used as screens in radio equipment on many bombers. He should also read the article published in the December, 1941, issue of "Plastics," page 240, entitled "Coating Plastics with Metal," which deals with the work sponsored by Plastic Spray, Ltd., of London.]

EXTRUDED PLASTICS

(Continued from page 23)

exceeds the extrusion speed, the tube is stretched while still hot and soft and is correspondingly reduced in diameter.

It is safe to say that the extrusion of plastics is still in its infancy and that, as extrusion equipment is improved and new uses are developed the tonnage of extruded plastics consumed will multiply greatly. Textile and related trades especially seem destined to be extremely large users, but the field can obviously be extended to include most industries.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

INDUSTRIAL CO-OPERATION.—We welcome the opportunity of publishing a letter from Mr. W. T. Cruse, Secretary-Treasurer to the Society of the Plastics Industry, New York, to the Secretary of The British Plastics Federation, Ltd. This is in answer to a suggestion by the Federation that it might be of mutual advantage to keep in close touch with one another and to exchange information from time to time.

Society of the Plastics Industry,
295, Madison Avenue,
New York.
December 12, 1941.

Mr. G. T. Beach,
Secretary,
The British Plastics Federation, Ltd.,
11-12, Pall Mall,
London, S.W.1.

Dear Mr. Beach,

I am pleased to receive your letter of October 24.

We will gladly see that you receive all of the bulletins which we publish henceforth. I am sending you several recent bulletins which we have issued.

The distribution of all industrial and defence materials in the United States is regulated by the Government through an agency called the Office of Production Management.

The thermosetting moulding compounds are now controlled by a Government Order. This in fact means that you cannot obtain materials of this class without authority, which in turn makes it impossible to use them for anything except direct defence or essential civilian supply applications. There are some minor deviations from this routine, but not many. The Government has proposed to place all of the thermosetting materials under a similar general preference rating order.

You will notice that we, in the bulletins I am sending you, have had meetings to discuss this Order. We are endeavouring to influence the Government to issue an Order that will allow for the distribution of thermoplastic materials on a pro-rata basis. This will give the industry more of an opportunity to handle the distribution in the semi-essential civilian and luxury class fields. The Order will probably be issued late this month or early after the first of the year.

We have a Technical Committee of the Society that has become increasingly active. One of our important undertakings will be to consider moulded plastic applications for military aircraft. The Germans, we find, have made interesting uses of these applications. At a recent meeting of the Society a member of the U.S. Army Air Corps Staff presented some moulded parts taken from a bombed German Junker 'plane. This actively stimulated our thinking. The Army is exploring the possibility of using thermosetting plastics in various ammunitions. The experimental work is well along.

I was especially interested in your statement that companies who previously specialized in fancy goods are now engaged in work for your Government. Would it be possible, and in accordance with the regulations, for you to give me a résumé of these changes? It would be a very significant interest to our industry.

We at one time considered the possibility of sending a representative to England to consult with your organization and other members of the industry to learn first hand what the plastics developments were which had come about as a result of the war.

Very truly yours,
(Signed) WM. T. CRUSE,
Secretary-Treasurer.

PACKAGING INDUSTRY COMMITTEE.—In view of the fact that packaging plays such a vital part in modern distribution, the British Standards Institution has created a Packaging Sub-committee.

With the spread of the war, the availability of the various materials used in packaging, such as tinplate, timber, paper and paper board, plastics, tin, lead, glass, etc., has steadily deteriorated, and it has now become necessary to examine carefully the packaging of all commodities with a view to recommending the elimination of packaging materials of all sorts wherever possible and recommending the most economic sizes for the balance that must be packed. We are now at a stage in the war where we have got to go down to the barest minimum and have indeed reached

With the present issue we reduce the size of "Plastics," thus conforming with the general trend in technical journalism during war-time.

Paper is a munition of war. To save it is to help materially in the conduct of war.

the level when the availability of packaging material may be the deciding factor as to whether certain commodities are made.

A Packaging Sub-committee, under the chairmanship of Lord Burghley, has been charged with the task of making recommendations to the Materials Committee of the Production Executive on the types and sizes of containers to be used. On the instructions of this Sub-committee, the British Standards Institution has set up committees representative of the packers, the container manufacturers and the distributive trades in each section of the prepacked goods trade to formulate proposals for their consideration. The situation calls for a complete sacrifice of the personal interests of all parties, and consideration of the problem in each trade from the point of view of the nation at war. The various Committees have been instructed to take into account in their deliberations the possibility of economizing in labour and manufacturing capacity at every stage in production, in transport and distribution and in retailing.

On the Committee, which is under the Chairmanship of Mr. John Ryan, we note the names of Mr. G. Beach, of the British Plastics Federation, and Mr. E. A. Blanch, of the Closure Manufacturers' Association.

B.A.B. FLUORESCENT SYSTEM OF LIGHTING.—Illumination of a fluorescent substance by rays of light within the ultra-violet region is no new thing, and has, in fact, in recent years been used extensively in laboratory analysis. Now, however, it is possible and practicable to use such illumination on a much greater scale. This development is largely a war one, although the way was demonstrated at the immediately pre-war exhibitions in Glasgow and Paris. To-day such illumination is an industrial and military asset of no unproved value, and an asset of which the country will make increased use as time goes on and the necessity for black-out conditions endures.

The B.A.B. system is a British one and supplies are therefore available in this country on a commercial scale. The system consists of painting a surface, for example, a curb, the frame of a doorway, guide lines on the ground, projections from walls, etc., with a fluorescent paint and illuminating it with light from either a mercury vapour lamp or a white light lamp, from both of which the visible light has been filtered by means of specially designed "black glass" filters which only transmit certain wavebands in the ultra-violet end of the spectrum. The light itself is invisible, furthermore, its wavelength is not injurious to the eyes, nor does it tan the skin, since the wavelengths range from 3,340 to 4,000 angstrom units. The dangerous waves which necessitate the wearing of goggles are shorter than this, being in the neighbourhood of 3,050 angstrom units. Any light source can be used, such as car head lamps, the ordinary tungsten filament lamps, searchlights, mercury vapour lamps or high-intensity gas lamps. All of these can be screened with the "black glass" filters which will filter out light of wavelengths other than 3,340 to 4,000 angstrom units.

The fluorescent material, for convenience, is supplied in the form of a high-grade lacquer. This is applied over a special white coating. The lacquer possesses sufficiently hard-wearing qualities and rapid-drying properties that it requires no protective varnish or other treatment. It will stand up to a good deal of abrasion without losing it fluorescence. The white undercoating can be applied to any surface—brick, concrete, wood, metal or fabric. The fluorescent lacquer contains no pigment and can be subjected to much harder usage than road-marking paint without any damage to its fluorescent properties. An added advantage is that, unlike luminescent paints, its fluorescent properties do not vary greatly with temperature. Hence it is still operative in frost.

The system is developed by Colloidal Research Laboratories, Ltd., of 70, Petty France, S.W.1.

SHELLAC RESTRICTION.—The Board of Trade announces that the open general licence permitting the importation without separate licence of shellac (including seedlac and sticklac) from the British Empire, Palestine and Transjordan, the Free French Colonies, the Belgian Congo and Ruanda-Urundi has been revoked from next Monday.

Separate licences will be required, but this will not apply to goods which are proved to have been despatched to the United Kingdom before January 26 and are imported into the United Kingdom before March.

BRITISH STANDARDS INSTITUTION.—At a recent meeting of the Chemical Divisional Council of the B.S.I., Dr. E. F. Armstrong F.R.S., who has been

chairman of the Divisional Council since its formation some 10 years ago, retired from the chairmanship, and Mr. Roger Duncalfe, president of the A.B.C.M., was appointed to succeed him.

Dr. Armstrong has for some time desired to be relieved of the chairmanship, particularly as he is fully occupied at the present time as chemical adviser to the Ministry of Home Security.

It is due to Mr. Armstrong that the chemical industry threw in its lot with that of the B.E.S.A., as it was then called, and co-operated in the enlargement of the scope of the standards organization to include, as it now does, the major industries of the country. The successful issue of the conference which took place between the B.E.S.A. representatives and those of the chemical industry was due in large measure to Dr. Armstrong's diplomatic handling of what was undoubtedly a matter fraught with many difficulties, and as the chairman of the chemical division, he had been responsible for the successful development of national standardization in the chemical field. It will be recollected that he was chairman of the B.S.I. in 1934 and 1937. He is chairman of the Finance Committee of the Institution, and, indeed, since the widening of its scope under its new title, the B.S.I. has owed much to Dr. Armstrong's ability and foresight.

The Institution is fortunate in having secured Mr. Roger Duncalfe, president of the Association of British Chemical Manufacturers, as Dr. Armstrong's successor.

GOVERNMENT TRAINING SCHEMES.—Under present circumstances it is essential that a considerable proportion of trainees should be placed in industry within eight weeks after entering training. It has therefore been decided to offer initially at Government Training Centres a course of from four to eight weeks, and in appropriate cases to give the trainee an opportunity of taking a longer course, which will normally be 16 weeks, with the prospect of more responsible and interesting work in industry after training. Increments will be paid normally at the end of the eighth and twelfth weeks of training to trainees who qualify for the longer course, subject to passing tests of proficiency. (In the case of draughtsmen the increments will normally be payable eight weeks and 12 weeks after entering the drawing office.) The new rates and increments can be obtained from the Ministry of Labour.

RUBBER DATA.—We have received from the British Rubber Publicity Association a copy of a circular chart entitled "Rubber Data for the Engineer." This is a cleverly constructed chart giving valuable thermal, electrical and mechanical properties of the various types of rubber: hard, soft, vulcanized, etc. A copy will be sent free and post free to any of our readers. Address: 19, Fenchurch Street, London, E.C.3.

BAKELITE, LTD. announce the following changes in their organization:—Messrs. W. E. Cooper, F. J. Robinson and G. Dring have been elected directors of the company and members of the Executive Board. Mr. W. E. Cooper has been appointed comptroller, Mr. C. C. Last general sales manager, Mr. G. W. Hodds purchasing manager, and H. H. Lusty marketing manager.

The other appointments remain as in the past:—Mr. H. V. Potter continues as managing director, Messrs. E. K. Smith, A. W. Sherwood and E. J. Lassen as departmental sales managers, and Mr. F. J. Robinson as works manager, Mr. G. Dring as development manager, and Mr. A. Lowe as technical assistant to managing director.

B.X. PLASTICS, LTD.—The Birmingham office of B.X. Plastics, 11, Albert Street, has been closed. All sales matters will be attended to by Mr. R. W. Greenstock at "Highams," 410, Warwick Road, Solihull, Birmingham. Telephone No.: Solihull 0599, where all inquiries should be made.

MR. N. F. ROSE, M.B.E., has been appointed a member of the Board of Cellon, Ltd. Mr. Rose joined the company on September 1, 1926, to represent them in Birmingham and district. In June, 1928, he was appointed Midland Area Manager and still holds that position.

MR. HERBERT P. BRIDGE, director of Thos. De La Rue and Co., Ltd., has been elected to the Council of the Radio Manufacturers Association.

The fact that goods made of raw materials in short supply because of war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

Resinoids and Other Plastics as Film Formers

By B. J. BRAJNIKOFF,
Consulting Electrical Engineer

V.—Synthetic Coatings of the Vinyl Family

THE perfection of the methods of utilizing resinoids is one of the most interesting and vital phases in the development of plastics, since the scale of their production is directly dependent on the extension of their industrial uses and applications.

No sound solution of a technical problem is feasible unless it is based upon relevant scientific data. For various reasons, such as the lack of correlation between discoveries and their utilitarian aspects, mental inertia, and others, it is inevitable that technology should lag behind the potentialities offered by the ever-rising level of science.

History of Vinyl Resins

The most striking example of the time-lag between the scientific achievement and appraisal may be illustrated by the history of vinyl chloride, which, since its discovery by Regnault[15] in 1835, took a century until the commencement of its exploitation in the U.S.A. in 1935, after the practical value of products of its polymerization had been recognized due to repeated efforts of research workers.[16]

Almost an identical fate has overtaken another promising member of the vinyl family—styrol.

The importance of compounds of the vinyl ester group in the realm of film-formation was already stressed in the second part of this work, where its general classification has been outlined.

There can be no doubt that, with the present state of knowledge, the coating industry can be enormously enriched by taking a fuller advantage of novel trends in the technique of resinoid treatment.

With the aim of reducing the gap between the strides of research and coating possibilities, the outstanding members of the vinyl family will now be analysed in greater detail.

Formation of Vinyl Resinoids

The term polyvinyl compounds comprises synthetic materials obtainable through polymerization of a substance of a general formula $CH_2 = CR_1R_2$, where R_1 may be hydrogen or alkyl group and R_2 an activating group, such as: Cl, –CN, –COOH. Some of these polymers, for instance, polymerizates of methyl acrylate: $CH_2 = CH - COOCH_3$, styrol: $CH_2 = CH.C_6H_5$, and vinyl chloride: $CH_2 = CHCl$, may possess rubber-like properties, whilst in other members of this group, for example, acrylnitrile: $CH_2 = CH - CN$, and methyl methacrylate: $CH_2 = C\ (CH_3)\ COOCH_3$, these features are absent.

In certain cases, polymers may acquire rubber-like characteristics, if they are treated with suitable plasticizers, resulting in such products that in time can, in a great measure, replace the natural rubber; the notable compounds of this type are polyvinylchlorides, which already find manifold applications, as exemplified by the Koroseal made in the U.S.A. by the Goodrich Co., Flamenol by the General Electric Co., and their corresponding German derivative—the homologue "Igelit." The plasticized polyvinylchloride products are known in America under the designation Vinylites and in Germany and Great Britain as Mipolam.

Side by side with the rubber-like synthetics of the polyisobutylene class, e.g., American Vistanex and German Oppanol, the Vinylites are finding ever-increasing utility as raw materials for the rubber industry, electrical and chemical technology, and others, having

a further advantage over rubber in that they can be made glass-clear.

Thus, for instance, the remarkable anti-corrosive properties of Koroseal (hence the trade name implying the substance for "sealing against corrosion") render it ideally fitted to form protective coating and impregnating compositions in solution form.

Rubber-like Resins

Another notable member of the vinyl family, as manufactured by the Du Pont Co. in the U.S.A., is polyvinyl alcohol. This product is a white odourless powder, with the specific gravity of 0.4—0.6, which, on being milled, forms an elastic mass, retaining elasticity within the temperature range from 30 degrees to 150 degrees C. The polyvinyl alcohol is soluble in water heated to 70 degrees C., in glycerine and glycol. By means of controlled swelling in water or glycerine, the polyvinyl alcohol may be converted into a product similar to rubber (known in the U.S.A. as Povimal and Polyviol in Germany).

The polyvinyl alcohol, stable to the action of mineral oils even at 140 degrees C., possesses a great resistance to ageing. It can be kept in storage as long as for six years almost without displaying any tendency to solidify.

Like the virgin rubber, the polyvinyl alcohol is vuncanizable by means of combining with sulphur. Its aqueous solutions are miscible with synthetic latices, forming emulsions. These emulsions are applied for coating rubber articles with the object of rendering them immune to deleterious effects of organic solvents, oils, oxidizing gases such as ozone and light.

The evaporation of water from an aqueous solution of polyvinyl alcohol leaves clear, colourless films, characterized by the possession of great resistance to attack of oils, fats, hydrocarbons, most of organic solvents, namely, benzene, gasoline, toluol, xylol, chloroform, carbon tetrachloride, carbon bisulphide, acetone, alcohol, ether. These films are also distinguished by their noteworthy impermeability to gases and strong adherence to the substrate.

The polyvinyl alcohol and its solutions in water are highly stable. The viscosity 1-5 per cent. of its aqueous solutions undergoes no change even on prolonged heating. Water solutions of the polyvinyl alcohol also form excellent binders and are employed as technical cements and glues.

Synthetic Latices

The latex-like systems obtainable by polymerizing polyvinyl resinoids are miscible in all proportions with the latex of natural rubber. Mixed latices in a water phase, with the concentration of the order of 20 per cent., may be coagulated by the addition of electrolytes, as, for example, by treating them with four-five-fold amount of 1 per cent. solution of acetic acid.

A mixed latex, containing up to 10 per cent. of polymer to rubber, coagulates almost instantaneously; a latex with the 20-40 per cent. content of polymer coagulates slower, but as well uniformly and completely; the coagulation of an artificial latex mix, having 100 per cent. of the polymer to rubber, fails to give a homogeneous product: the component parts of such a system coagulate independently, with the resultant separation of bodies formed.

Films derived from the synthetic latices are noted by high stability to the action of solvents, oils, fats, light, oxygen, and heat.

Synthetic latices, being more stable than the natural stock, can be compounded with a much larger volume of fillers than is permissible with the rubber latex, leading to enhanced variety and economy of final products.

Latices composed of vinylacetate and esters of acrylic acid yield tough, resilient films which are marked by strong adhesion, transparency to ultra-violet light, and are, therefore, very durable. They are used in the making of artificial leather, for impregnating cloth, as

binding medium in the production of cardboard, etc.

Methacrylate resins are distinguished by the possession of quite unusual properties for film-formation, adherence and bonding force. They easily furnish emulsions, which prove that they will have an extensive usefulness in the coating sphere, as coverings and impregnants, especially in the manufacture of leather substitutes, in the treatment of textile fabrics, and the multitude of others.

These products are also utilized in the technology of rubber for the purpose of imparting to it the desired properties.

Range of Latex Systems

Besides the ease of preservation, the synthetic latex systems are convenient for handling through controlling the degree of concentration from emulsions to pastes and the reverse by dilution with water, from which the latices can be coagulated by freezing or by electrolytic agents.

The latter operation offers, thus, an opportunity for taking the advantage of cataphoretic phenomena by means of the electro-coagulation process.

This procedure, in turn, opens up further prospects of electro-deposition of synthetic resins on metals, in much the same way as deposition from aqueous suspensions of insulating materials as effected, for example, by the well-known anode process for rubber latex.[17] The typical embodiment of the electro-chemical deposition from rubber sols is the anode ionic process as developed in America by the Eastman Kodak Co., and other pioneers.[18]

A corresponding method for hydrophobic media, based on experiments with polymeric styrene methyl methacrylate polymer, butyl methacrylate polymer, and an alkyd modified urea-formaldehyde resin, has lately been suggested by Gemant[19] in the U.S.A.

Qualitative observations on the film-forming behaviour of the examined resinoids showed that the process seems particularly suited for electrodeposition of the highest-grade insulating layers on metallic bodies, but necessitates the use of costly oils as the dispersing phase of the suspensions, and is handicapped by the inherent slowness of the procedure.

Compared to the above, the operational efficiency of hydrophilic systems is, of course, immensely higher, as may be deduced from considerations that follow.

Like the natural latex, colloidal particles of resins dispersed in an electrolyte, e.g., alkaline media, are negatively charged due to adsorption of hydroxyl ions liberated from the anode.

So long as macromolecular units in suspension retain their charges, in spite of ceaseless oscillations (Brownian movement), they are prevented from cohesion and coagulating by the electric repulsion. Through neutralizing the hydroxyl anions, the repelling force between particles is removed, setting thereby cohesional work in motion and resulting in coagulation.

The linear progress of the process, as a function of unidirectional electric current, permits the rapid deposition of homogeneous films (anchored or free) in one operation, thus obviating the plurality of coatings, with intermittent application of priming and top coats as required by the orthodox practice.

It also allows the development of continuous non-permeable layers at a uniform thickness appreciably less than is possible with coatings formed in ordinary manner.

Further advantages of the method are reflected in the improved physical characteristics of electro-deposited films, where hardness, toughness and adherence to the base are definitely raised, thereby greatly impeding the coating degradation, such as checking, cracking, sealing, flaking and resultant decay of the substrate.

For these reasons the electric-chemical method should ensure a longer serviceability of films exposed to the effects of severe climatic conditions.

Film Formation of Vinylacetylene

In the synthesis of new film-forming substances the recent theoretical and

experimental researches of the Russian Academy of Sciences are very significant. In addition to the valuable results achieved, it is the first attempt on record to systematize the scientific data in the coating field, based upon a comprehensive plan of co-ordinated team work.

Having no accumulated facts in this unchartered field and basing their efforts, chiefly, on the analogy of rubber, the Russian Institute of the Organic Chemistry selected the vinylacetylene as a starting material for the evolution of new film-forming and kindred utility products.

The work, which since 1935 has been mainly concentrated at a specially equipped Laboratory of High Molecular Compounds in Moscow, has been conducted under supervision of the leading Russian petroleum technologist, I. N. Nazaroff, and under the general guidance of the Academician A. E. Favorsky.

Simultaneously, intensive developments have also been carried out in co-operation with such organizations as the Russian Plastics Institute, Azerbaijan Petroleum Research Institute at Baku, Caucásus, Russian Electrical Research Association, the Mendeleeff Institute of Chemical Engineering, Paint and Varnish Institute, and others.

Since the volume of studies performed precludes their complete account here, only a few cardinal points bearing on the chemical, physical, and technological aspects of the original methods for synthesizing various oxygen-containing derivatives of vinylacetylene, their polymerization and film-formation will be discussed.

The adoption of the vinylacetylene as a raw material was due to the fact that it already contains an unsaturated group in the shape of the conjugated double and triple bonds, which, on theoretical grounds, is indispensable in order to render an organic molecule capable for the polymerization. Consideration of the availability of supply of the vinylacetylene was an important corollary in its choice, since it has been made the basis of the manufacture of the new synthetic rubber " Sovprene " in Russia.

The fundamental problem of investigations has been that of finding efficient technical methods for synthesizing such derivatives of vinylacetylene, which would give films with properties specially suitable for various industrial purposes. Since such vinylacetylene derivatives have not been previously known, the solution of the problem, of necessity, had to be made in the original manner.

The task was also complicated by the circumstance that at the present time it is impossible to foresee what products of this kind of compounds would best meet the case.

Hence the most rational way of attacking the problem could be through synthesizing an extensive range of derivatives with the diverse constitution and structure that would permit a selection of the best products, from the standpoint of both their technical qualities and the cost of manufacture.

The Scope of Synthesis. Vinyl Esters

The results of the above experimental studies may be briefly summarized:—

First of all an attempt has been made to synthesize unsaturated esters of the vinylpropiolic acid. One of these acids—the vinylpropiolic acid itself—described by Carothers, speedily polymerizes into a solid transparent mass and is distinguished by an extreme sensitivity to the oxygen of air. All the above properties indicated that complex esters of this type should possess the ability for polymerization as well.

Nazaroff[20] has obtained these esters by means of the following series of transformations:

$$CH_2=C(R_1)-C\equiv CH + NaNH_2 \longrightarrow CH_2=C(R_1)-C\equiv CNa,$$

$$CH_2=C(R_1)-C\equiv CNa + CO_2 \longrightarrow CH_2=C(R_1)-C\equiv C-COOH,$$

$$CH_2=C(R_1)-C\equiv C-COOH + R_2OH \longrightarrow CH_2=C(R_1)-C\equiv C-COOR_2,$$

where: $R_1 = H$ or CH_2; $R_2 = CH_3, C_2H_5$, iso $-C_5H_{11}$ and the residue of glycol.

Nazaroff has shown that, in contradistinction to acids, these esters derived from the foregoing entirely new original

reactions, are relatively stable compounds, which can be easily distilled, purified and obtained chemically pure. They are a colourless liquid having a very pungent odour, irritant to the eyes and skin. These esters, depending on the character of the alcohol radical, are more or less rapidly polymerizable.

Vinylethynilcarbinols

The next group of reactions relates to the preparation of the so-called vinylethynilcarbinols with the aim of using these unsaturated alcohols for further synthesis of series of esters of different structures. The study of the resulting products (the primary, secondary and tertial vinylethynilcarbinols) proved them to be stable combinations, readily distillable in relatively low vacuo.

In the presence of antioxydants, impeding the polymerization, they may be preserved unaltered for several months, but in absence of the stabilizers, they all, without exception, polymerize with different velocity, depending on an individual structure of these alcohols. Passing through a stage of gradual thickening, from a clear mobile liquid to the consistency of glycerine, they are transformed into a gel, soft at first, then beginning to solidify, until finally it is converted into a colourless, transparent, very hard, vitreous mass.

It has also been found that, under certain conditions, these carbinols may be very easily esterified by treatment with the most diverse alcohols (of the mono- and polyhydric type), the reactions resulting in high yields of respective simple esters. All these esters, obtainable in chemically pure state, are stable compounds, easily distilled in vacuo, being a colourless liquid, which gradually passes into gel with the ultimate conversion into a more or less resilient, elastic body.

The Nature of Polymers

The character of a polymer depends, to a great extent, on the nature of an alcohol radical, the greater the magnitude of the latter the more the plasticizing effect on the polymer. Note should be made of the following interesting regularities in the structural influence on the velocity of polymerization of these kind of compounds.

The esterification of the hydroxyl group, its conversion into alcoxyl group, considerably retards the rate of polymerization, so that simple esters polymerize three-four times slower than the corresponding vinylethynilcarbinols. The hydroxyl in these combinations, obviously, plays an active rôle in the polymerization process.

In addition to esters of monohydric alcohols, were also prepared the esters of glycol, which are clear, colourless, odourless, more or less viscous liquids, polymerizable on standing. The monoglycol or oxyethyl esters may also be derived from the vinylethynilcarbinol ethylene oxide. Further, it is possible to obtain mono- and di-esters of glycerine, as well as simple esters of the vinylethynilcarbinols themselves, the polymerization of which takes place very slowly.

Finally, on the basis of monoglycol or oxyethyl esters of the vinylethynilcarbinols there is actually a possibility of obtaining an almost infinite range of new products by means of their esterification with any acid. For example, on being esterified by the acetic acid, they yield quite colourless polymer.

The esterification of the oxyethyl esters of the vinylethynilcarbinols may also be studied with the aid of acids of high molecular weight, in particular with oleic acid, which recently gave rise to the problem of approaching under this angle the utilization of acids of the non-drying and semi-drying oils. Oxyethyl esters are also easily esterified by treating them with the phthalic anhydride, with formation of the corresponding monophthalic esters.

Synthesized compound esters of the vinylethynilcarbinols all displayed the ability for spontaneous polymerization. The study of a series of homologues of divinylacetylene, derived by dehydrating vinylethynilcarbinols with the aid of sul-

phuric acid, showed these hydrocarbons capable of self-polymerization on standing; a thin layer of the polymer in a day or two forms a hard, transparent film of yellowish colour.

Vinylacetylene Reaction with Organic Acids

Another series of products which proved themselves as film-formers has been derived from the additive reaction of uniting the vinylacetylene with organic acids. Although this reaction was described in the U.S.A. in 1933 by Verntz, who showed that the resultant products are compound esters of Cutadienol-2, the conditions for conducting the process have not been found; this merely established the possibility of combining with acids and produced negligible yields.

By subjecting this reaction to repeated studies, Nazaroff and his co-workers have succeeded in attaining much greater yields of the reaction products, viz., of the order of 50 per cent. in the case of the acetic acid (as compared with 7 per cent. of the American yield), and 70 per cent. for formic acid.

These products polymerize, give rubbery polymers of different degrees of elasticity, resilience, etc., which also may find uses in various types of coating compositions.

Finally an old and well-known reaction has been examined—the combination of organic acids with acetylene, the technological principles of which, according to a great many patent specifications, have been firmly established. The polymerization mechanism, the nature of polymers and their capacity for film formation, were investigated with the object of employing these compounds for the preparation of various film-forming products and evaluating properties of the resulting coatings.

Mechanism of Film Formation

It is important now to inquire into the nature of the process of conversion of these reaction products into films.

According to Nazaroff, in a number of cases a pure polymerization process is the dominant feature. This view is supported not only by the external transformation of matter from a mobile liquid into a solid, transparent, almost colourless polymer, but is also proved by determination of molecular weights up to a definite stage of thickening. The oxidation process observed in many instances (e.g., in polymerizing esters of vinylpropiolic acid) is slight.

Nazaroff emphasizes that a colourless appearance of polymers formed by these compounds testifies that in very many of them perhaps the oxidation in the process of film formation is completely absent.

Thus, the study of the said compounds has confirmed Nazaroff's postulation that a system of conjugated double and triple bonds, especially in a molecule of not very large weight, is sufficient in order to impart to these products the capacity for polymerization and film formation. The polymerization process of compounds of this kind depends, in addition to a number of factors, on the character of polymers. The velocity of polymerization, besides the constitutional influence and the powerful action of catalysts used, is also affected by various physical agencies, first of all by light and temperature. The rate of the polymerization process is readily controllable by the worker; it may be retarded for many months, or it can be realized literally within a few minutes.

The Behaviour of Polymers

All these polymers are irreversible. None of them is soluble in any of the known solvents; some of the polymers swell under the continual action of solvents, particularly of hydrocarbons. On heating above 130 degrees to 150 degrees C., some polymers soften and some of them fuse; a few polymers begin to darken and undergo chemical changes. The elasticity of polymers of the foregoing products fluctuates within very wide limits, from the organic glass, entirely hard, transparent, almost colourless body, up to the elastic mass of rubber-like materials. Between these two

extreme limits there exists an unbroken chain of gradual transitions with regard to the character of a resultant polymeric compound.

Clearly, this affords the possibility, by combining different types of polymers, for obtaining products of a desirable quality in respect of hardness, toughness, elasticity, etc. It should be noted that many of these substances are capable of cross-polymerization, by means of which almost an endless variety of new compositions can be produced.

A mixed polymerization, as a rule, results in the summation of polymeric features of individual components and is, therefore, a very efficient method for improving coating stock.

The polymerization may be carried out in the solution form, although in this medium its progress is rather slow. An increase of the viscosity on standing may be easily averted with the help of anti-catalysts admixed during the polymerization. Coating compositions prepared from these products may be preserved without any alterations in viscosity for half a year and longer.

Of special importance is the fact that all these derivatives are distinguished by the possession of an extremely high adhesive power, this property being perfectly general, admitting not a single exception.

The comprehensive tests that have been carried out with products of this nature showed that a well-organized research on the direct chemical synthesis of coating media is a sure means for contributing a valuable share to the solution of this difficult problem.

(To be continued)

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NEW CHRYSLER FEATURE

Plastic steering wheels that harmonize with the instrument panel and other plastics are a feature of the 1942 Chrysler cars. A wide choice of plastic colours is offered without extra cost. The 1942-type steering wheel is of the two-spoke variety, which gives the driver clear vision when looking at the road or at the instruments, which are placed directly in front of the wheel. Figures on the various dials are large enough to be easily legible to the driver from his natural position.

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